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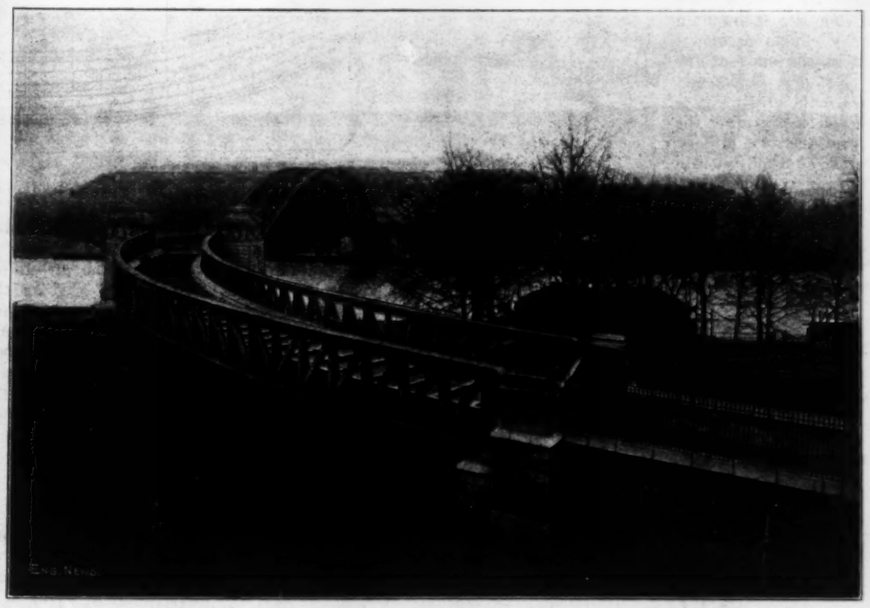
CURVED GIRDER APPROACH VIADUCT OF THE AUSTERLITZ BRIDGE OVER THE SEINE.

By R. BONNIN.*.

The line of the Metropolitan Railway of Paris, which connects the Place d'Italie with the Place de la République, crosses the Seine on a steel arch bridge already described in Engineering News.† On the right bank of the Seine this crossing is approached by a viaduct over the quays, located on a sharp curve of the line, making almost a right angle and with a radius of 246 ft. As it was necessary to avoid obstructing the pedestrian and street traffic on the quay, a steel viaduct of two spans became necessary. These spans might have been constructed with straight main girders of usual type, spread sufficiently to contain between them the curved lines of the two tracks; but this arrangement, previously adopted on the exterior boulevards, involved certain technical difficulties and from an esthetic viewpoint was far from perfect. It was therefore considered preferable at the Austerlitz bridge to make use of curved main girders, paralleling the curve of the track as the photographic view Fig. 1 shows. This is, we believe, the first application of such an arrangement either in France or abroad. It yields a metallic structure more agreeable to the eye, and having as only objectionable feature a greater shop cost than straight girders.



GENERAL VIEW OF CURVED-GIRDER APPROACH VIADUCT; PARIS METROPOLITAN RY.

We give in an appendix to this article a general theory of curved girders; in this place we confine ourselves to stating summarily the essential difference between the curved girder and the straight girder, by pointing out the additional forces to which it is subjected.

When a span *AB* (Fig. 4) is crossed by two straight girders *ab* and *cd*, any uniform load on *AB* subjects the two girders to equal bending moments and equal shears. The stresses in the two girders are therefore equal, and in consequence the two will be identical in make-up and sections. But when the span *AB* is crossed by a curved bridge having the axis *AmB*, with curved girders *a' m' b'* and *c' m'' d'* parallel to this axis, then a uniform load on the bridge produces a torsional moment tending to turn the bridge around its longitudinal axis *AmB*. As a result of this, the exterior girder must carry an excess load, while the load on the interior girder is reduced, as indicated by the sketch Fig. 5. The bending moments and shears of the two girders are then no longer equal, and they must be designed with different sections.

To resist the tendency of the trusses or girders to warp toward the outside of the curve, the posts of the girders and the floor beams of the roadway must be designed of such strength and must be so interconnected as to form rigid cross-frames capable of resisting the distorting forces so as to prevent transverse deformation. When, as in the case of the Austerlitz viaduct, the curved girders cover two consecutive spans elastically continuous with each other, and, moreover, rigidly connected to the supporting bents, the effects of continuity and fixed-end condition modify the results applicable to a single span and render the analysis more complex.

Fig. 2 gives a plan and a side elevation of the Austerlitz viaduct. The roadway has a gradient of 4% upward toward the river and, as already noted, its center line curves to the right with a radius of 246 ft. The two spans have a length, measured along the curved center line, of 106.4 ft. and 124.2 ft. respectively, giving a total curved length for the metallic portion of the viaduct of 230.6 ft. between centers of end supports. The two girders of each span are spaced 26 ft. 3 ins. apart and, as already stated, each is continuous across the two spans and is rigidly connected with the post of the intermediate bent *BD*, as also with the steel supporting bent *AE* (Fig. 6) at the river abutment. At the land end of the viaduct the girders rest on roller bearings on abutments fashioned in the masonry viaduct which continues the line. The bents *AE* and *BD* foot on pin bearings on their piers.

The girders are each 9 ft. 11¼ ins. deep and are of heavy riveted construction. The chords are of U-shape, with two webs and a cover plate. The web system is of the Pratt type, and its members are generally of riveted I-section. Each vertical is heavily bracketed to the floor beam connected with it, so as to resist the transverse warping effect due to the curvature of the girder. For the reasons already noted, the two girders of each span are quite different in sections, although of equal height and width. They are designed for maximum stresses of 15,000 lbs. per sq. in., including dead load, live load, wind, expansion and train-braking stresses. The roadway is composed of brick arches sprung between the floor beams and a ballasted roadway constructed on the floor thus formed.

This viaduct was designed in all details and built by Messrs. Daydé and Pillet, under the direction of the engineers of the Metropolitan.

Appendix: General Theory of Horizontally Curved Beams.

The following is a general theory for the calculation of curved bridges, whatever be the manner of support of the main girders. The discussion is based on studies made a short time ago by Mr. Résal, Chief Engineer of the Ponts et Chaussées.

Referring to the diagrammatic plan Fig. 7, *AB* is the horizontal projection of one segment of a main girder between two successive cross-frames *E* and *E'* and adjoining an element *BC* not in the same straight line with *AB*. Any bending moment in the vertical plane of segment *AB* can be resolved into two component moments, one in the plane of segment *BC* and the other in the plane of the cross-frame *E'*. To make this more clear, the assemblage of elements is shown in perspective in Fig. 8, whose lettering corresponds with that of Fig. 7. Here a bending moment in the plane *ABA'B'*, represented by the couple m_1 [or otherwise by the two equal forces P_1 and P_1' acting in the upper and lower flange respectively], may be decomposed as shown by resolving each of the two flange stresses into the components P_2, P_3 and P_2', P_3' acting in the

*61 Rue Louis Blanc, Paris, France.
†Dec. 7, 1905, p. 604.

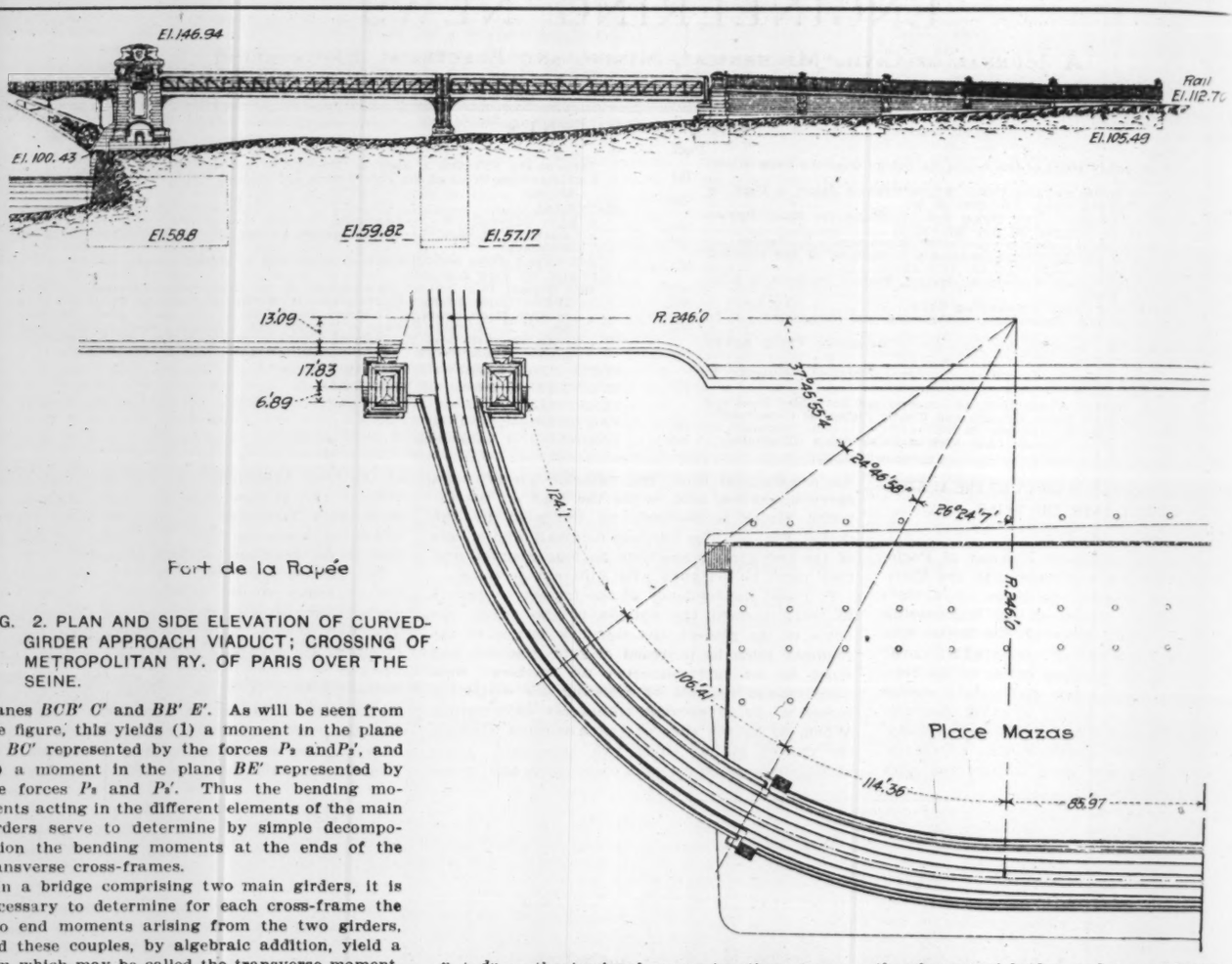


FIG. 2. PLAN AND SIDE ELEVATION OF CURVED-GIRDER APPROACH VIADUCT; CROSSING OF METROPOLITAN RY. OF PARIS OVER THE SEINE.

planes $BCB'C'$ and $BB'E'$. As will be seen from the figure, this yields (1) a moment in the plane of BC' represented by the forces P_2 and P_2', and (2) a moment in the plane BE' represented by the forces P_3 and P_3'. Thus the bending moments acting in the different elements of the main girders serve to determine by simple decomposition the bending moments at the ends of the transverse cross-frames.

In a bridge comprising two main girders, it is necessary to determine for each cross-frame the two end moments arising from the two girders, and these couples, by algebraic addition, yield a sum which may be called the transverse moment, or the *moment of torsion*, for the cross-section under consideration. This moment n is counterbalanced, as indicated in Fig. 9, by an equal opposing couple made up of two vertical forces Q acting at the end connections of the cross-frame to the main girders. This results in putting an additional load upon the outer main girder and decreasing the load upon the inner main girder. The additional forces Q may better be considered as a separate system of loads upon the main girders which give rise to an additional set of bending moments in the girders to be added to the original moments which were used for determining the torsional couples n.

In a bridge whose girders are curved in ground plan, in any curvature whatever (Fig. 10), consider two neighboring sections MN and $M'N'$ separated by a very small distance. Let

ds = the distance between the cross-sections, measured on the center line of the bridge;

m and m' = the bending moments in the main girders, acting in the direction of the tangents MO, NO';

n = the torsional moment at the section MN;

$n + dn$ = the torsional moment acting at section $M'N'$;

e and e' = the angles between tangents to the main girders at the two cross-sections;

b and b' = the angles between the tangents $M'O$ and $N'O$ and the section $M'N$;

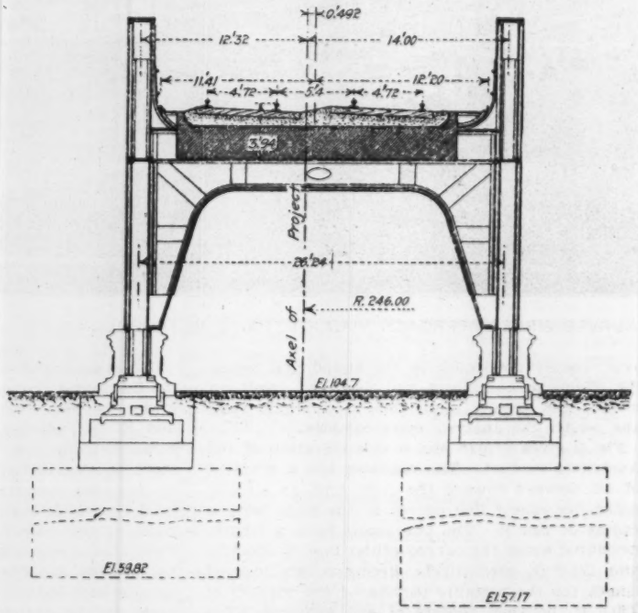


FIG. 3. CROSS-SECTION OF CURVED-GIRDER VIADUCT AT INTERMEDIATE BENT.

c = the central angle between the planes of the two cross-sections.

The transverse distance between the girders at the element of bridge under consideration is denoted by $2a$.

The torsional moment n and the bending moments m and m' may be resolved into moments acting in the direction $M'O$ and $N'O'$ and the direction $M'N'$. As the angles b and b' differ very little from 90° in any practical case, the moments in the direction of the tangents $M'O$ and $N'O'$ need not be considered, since, being perpendicular to the section $M'N'$, they do not contribute to the torsional action at that section. The moments in the plane of the cross-frame $M'N'$ from the three original moments above noted are

$$\left.\begin{array}{l} n\cos c \\ m\sin e \\ m'\sin e' \end{array}\right\}$$

The sum of these moments must be equal to the torsional moment at section $M'N'$, or $n + dn$. We may therefore write, replacing $\cos c$ by its equivalent in terms of $\sin c$,

$$n\sqrt{1-\sin^2 c} + m\sin e + m'\sin e' = n + dn$$

Since the angle c is very small, the term $\sin^2 c$ is of the second order, and vanishes. Similarly, the terms $\sin e$ and $\sin e'$ may be replaced by e and e' respectively. We have then

$$n + m\,e + m'\,e' = n + dn,$$

or,
$$m\,e + m'\,e' = dn \qquad (1)$$

Considering now the force Q of Fig. 9, let the amount of this force per unit length of bridge be denoted by q. Evidently the increase of torsional moment, dn, must be equilibrated by these vertical forces q distributed over the length of the bridge between the two neighboring sections MN and $M'N'$. We can then write

$$dn = 2\,a\,q\,ds \qquad (2)$$

from which, by equating the values of (1) and (2), we obtain

$$q = \frac{m\,e + m'\,e'}{2\,a\,ds}$$

Accurately speaking, the terms m and m' in this equation are the actual final moments in the main girders, which of course are unknown until the terms q have been computed. To approximate the values of q, however, we may replace

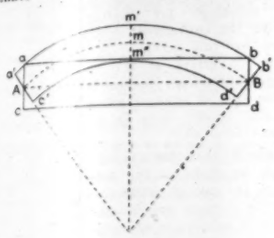


Fig. 4.

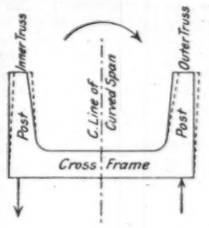


Fig. 5.

m and m' by M and M', representing the moments in a corresponding straight girder, which moments are readily calculable. As it is found in practice that the quantity $M\ E + M'\ E'$ differs very little from $m\ e + m'\ e'$, the approximation is sufficient for practical purposes.

Thus, having calculated the straight-girder bending moments M and M' for the main girders,

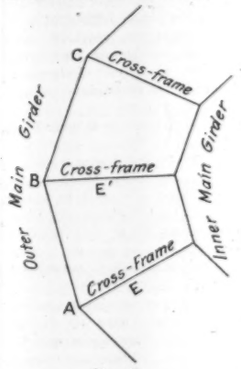


Fig. 7.

the values of q for any point along the length of the girder may be calculated by the formula

$$q = \frac{M\ e + M'\ e'}{2\ a\ ds} \qquad \ldots\ldots\ldots\ldots (3)$$

The supplemental loading formed by these forces q produces in the main girders an additional

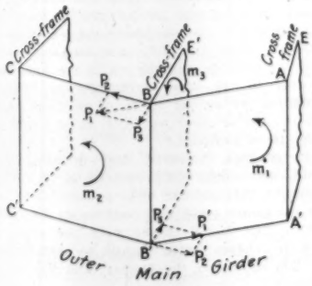


Fig. 8.

bending moment, which can be calculated without difficulty. For this purpose, the quantities q are to be separated into their components q' and q'', acting respectively on the outer and the inner girder. These are

$$q' = q\ \frac{r}{r + a}$$

and

$$q'' = q\ \frac{r}{r - a}$$

From these the supplemental bending moments in each girder are calculated by ordinary methods.

For instance, in the case of a curved bridge having continuous girders, the supplemental moment N at any point D (Fig. 11) of the outer girder will be

$$N = N_a + R_a\ d - \int_0^d q\ (d - x)\ dx$$

in which equation N_a and R_a are the bending moment and shear at the left-hand support A under a loading consisting only of the forces q'; d is the distance of point D from the left-hand support; and x is the variable distance of the intermediate

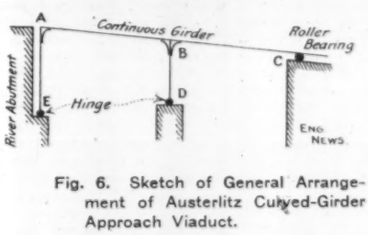


Fig. 6. Sketch of General Arrangement of Austerlitz Curved-Girder Approach Viaduct.

points between A and D from the left-hand support. Similarly, a point D' of the inner girder will have the supplemental bending moment

$$N_a' + R_a'\ d - \int_0^{d'} q''\ (d' - x)\ dx$$

The total or actual bending moments in the two girders then will have the respective values $M + N$ and $M' + N'$, the proper algebraic signs being given to the several quantities.

It will be noted that the moments N and N' will in turn give rise to transverse or torsional moments, and in consequence to an increase or decrease of the vertical load on the two girders, which may be calculated as before. But as the quantities N and N' are of opposite sign and differ but little, the expression $N\ e + N'\ e'$ which would enter into such calculation is always small and negligible in comparison with $M\ e + M'\ e'$—in which latter term M and M' are in general of the same sign. In practice, therefore, it is sufficiently exact in most cases to compute the supplemental moments N and N' from the straight-girder moments M and M', without carrying the approximation farther.

When the expression for the total moments has been found, the shears are easily determined by differentiating the expression for bending moment; or, the forces q having been determined, they may be combined with the primitive system of loading due to dead and live load, thereby giving the actual amount and distribution of loading from which the shears can be found by funicular polygon.

The design of the cross-frames and the posts

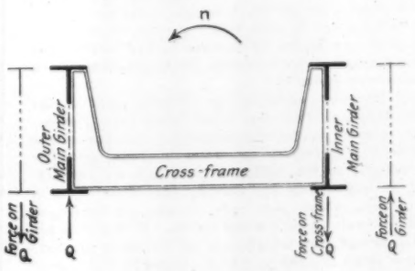


Fig. 9.

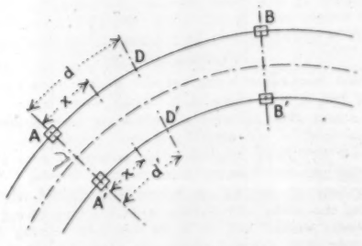


Fig. 11.

involves no difficulty when once the torsional moments as calculated by formula (1) have been found. Thus, in Fig. 12, n_1 and n_2 represent the torsional moments at a given cross-frame, due to each of the main girders, and, as before, the equilibrating forces Q are obtained by the equation

$$Q = \frac{n_1 + n_2}{2\ a}$$

For calculating the bending moment in any section S-S of the cross-frame due to the torsional action in the bridge, the formula evidently is

$$\text{Moment} = n_2 - Q\ k_1$$

where k_1 is the distance of the section from the right-hand end of the cross-frame.

For the purpose of calculating the moment in the post when the cross-frame is of the portal form shown in Fig. 12, the end moment n_2 will first be converted into the couple $Q'\ h$, consisting of the horizontal forces Q' acting at the chords of the girder. That is to say,

$$Q' = \frac{n_2}{h}$$

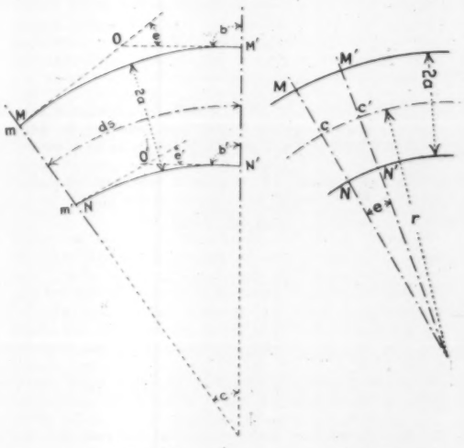


Fig. 10. Fig. 13.

Then the bending moment in the post at any section T-T will be

$$\text{Moment} = Q'\ k_2 = \frac{n_2}{h}\ k_2$$

In the case of both post and cross-frame, the moment due to the torsional couple is of course to be combined with the moment due to the loads on the structure, calculating these latter moments as though the cross-frame were simply supported at either end.

When the curvature of the bridge is circular and the two girders are concentric curves, the expressions previously given become somewhat simpler. Thus, if r is the radius of the center line of the bridge and $2a$ the distance between girders, e the angle embraced between two transverse sections separated by unit length cc' in the axis of the bridge (Fig. 13), then

$$e = \frac{1}{r}$$

and substituting in equation (3) we obtain the simplification

$$q = \frac{M + M'}{2\ a\ r}$$

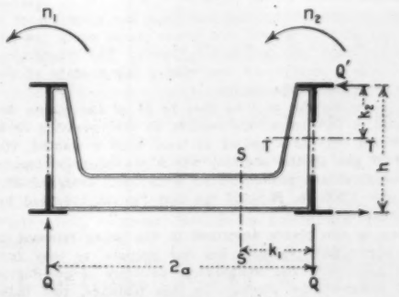


Fig. 12.

The principles employed in the foregoing are applied in exactly similar manner to the calculation of stresses due to wind and to the traction or braking of trains. The first step is the calculation of what we may call the primitive

moment: that is to say, the moments which would be produced in a similar structure straight in plan. Then the torsional moments n are computed therefrom, and the resulting supplemental loads q applied as corrections to the previously recognized external loading.

RELATIVE ECONOMY OF STEAM AND GAS POWER WHERE EXHAUST STEAM IS USED FOR HEATING.*

By F. W. BALLARD.†

The present time, when the gas engine is becoming so popular, is a good one to make a comparison between the cost of power generated by the gas engine and the cost of power from steam, when conditions are such that either the heating of buildings or the carrying on of some of the processes of manufacture can be accomplished by the use of exhaust steam from the steam engine.

It is generally conceded that when the power alone can be used, and the waste heat from the steam engine and gas engine is not utilized, the gas engine is the more economical power producer. This is no doubt true under the usual conditions, for the gas engine has the advantage of being the most economical prime mover we have as far as fuel consumption is concerned. It has also been shown that in a modern, well-designed gas-engine plant the cost of maintenance need not be more than half what the cost of repairs would be in a steam-power plant of the same capacity; the cost of labor also would probably not run much over half what the service account would total in the steam plant.

COST OF FUEL.

However, it is not always possible to use as cheap fuel in the gas engine as can be found available for consumption under the boilers of the steam plant. We can use the cheapest grades of coal to advantage for the generation of steam; but we must manufacture gas for the gas engine, if natural gas is not available; and while the best results we can get with the highest type of steam plant is 1 HP.-hr. for about 20,000 heat units, we can get the same power from the ordinary gas engine with the consumption of only 9,000 or 10,000 heat units. Yet this vast difference in economy may easily be offset by the difference between the cost of the coal and the gas.

Twenty cts. per 1,000 is about the lowest limit we can reach in the manufacture of artificial gas, and 30 cts. per 1,000 is the price which must be paid for natural gas at nearly every place to which it has been piped in this state; and these prices, namely, 20 cts. for artificial and 30 cts. for natural gas, are not far from the same value per heat unit, natural gas having a thermal value of about 1,000 B. T. U. per cu. ft., and coal gas about 650.

If 1 brake HP.-hr. can be produced by the gas engine with 10,000 B. T. U., as we have just stated, this would mean a consumption of about 10 cu. ft. of natural gas, which would represent a cost for fuel of about 0.3 ct. Assuming a cost of coal of $1.50 per ton, which is a fair average for the grades used in the general run of power plants, and a thermal value of 14,000 B. T. U. per lb., we find in the steam plant mentioned above, which is generating 1 HP.-hr. on 20,000 heat units, that the cost for fuel will amount to about 0.1 ct. per HP.-hr. Thus, under the conditions which are most generally found in the great majority of power plants in this state, the cost of fuel in a steam plant would be less than the cost of fuel in a gas-engine plant of the same capacity.

COMPARISON FOR STEAM AND GAS ENGINE PLANTS.

The above figures are to a large extent theoretical, and would, no doubt, be difficult to realize in both the steam and gas engine plant under the practical conditions of continuous operation. In this connection some information given by Mr. J. R. Bibbins in a paper read before the American Institute of Electrical Engineers in December, 1903, is particularly valuable, as it consists of records of results obtained from the operation of a number of electric-light and power plants using gas engines as their principal motive power. The records extend over a long period, and give a fair average of the cost of power in the station.

It is interesting to note that in 11 of the plants described in this paper, the records on the operating costs of which covered a period of from 4 to 9 months, the cost of gas at the engines, which consisted principally of artificial gas manufactured from coal, averaged 33.9 cts. per 1,000 cu. ft.; and the cost for gas averaged 1.4 cts. per KW.-hr.

Two of the plants described in the paper referred to are particularly valuable for our purpose, as they furnish data upon the comparative economy of gas-engine and steam-engine plants. In this instance, two independent stations were operated, one with steam engines and the other with gas engines run in connection with a gas works. The cost of fuel in the steam plant was 1.38 cts. per KW.-hr., and in the gas plant 0.75 ct. per KW.-hr.

In this plant Mr. Bibbins estimated that 92,000 heat units were required per KW.-hr. in the steam plant, and only 29,100 heat units in the gas-engine plant. These figures represent the average results as shown by the records for a year's run. Both these plants ran from 15 to 18 hrs. per day, the steam plant consisting of compound condensing engines and water-tube boilers. The steam plant was of 1,250-HP. capacity, and the gas-engine plant of 685-HP. Another plant described in this paper, having about 800-HP. capacity and operated, during the period covered by the records, first by steam engines and afterwards by gas engines, showed the following results: The total fixed charges on the steam plant, including interest on the investment, depreciation on buildings and machinery, taxes, insurance, etc., amounted to $22.30 per brake-HP. per year. The net operating cost was $36.40, making a total cost of $58.70. In the gas-engine plant the fixed charges amounted to $15.20 per brake-HP. per year, and the net operating cost was $14.80, making a total cost for power in the gas plant of $30.50 per HP. per year.

These figures are certainly favorable to the gas-engine plant as far as the cost of operation is concerned, and I believe that it is generally conceded that where it is not necessary to use exhaust steam for heating, and where reliability in the way of continuous operation is not necessary, the gas engine has the advantage.

EXHAUST STEAM FOR HEATING.

However, the feature which gives the steam plant a decided advantage over the gas plant in the way of economy is the possibility of using the exhaust steam from the engine for heating. Of course, this precludes the use of condensing apparatus in connection with the engine, and consequently lowers the economy of the steam plant considerably; but since the latent heat contained in the exhaust steam amounts to about 80% of the total heat of the steam before going to the engine, the lowering of the efficiency incident to running the engine non-condensing becomes of minor importance. In fact, it would be more proper for us to consider the power generated from the steam before it goes to the heating system as a by-product of our steam-heating plant.

Of course, there are a great many plants in operation at the present time where it is not possible to make use of the exhaust steam, but by far the great majority are situated ideally for profiting in this way. All power plants in large office buildings, for instance, come under this class; and most manufacturing companies have buildings to be heated which will utilize most, if not all, of their exhaust steam. In addition to the heating of buildings, a great many of the manufacturing concerns can make use of the heat of the exhaust steam for carrying on certain processes necessary in their work, thus saving the use of live steam.

LIVE STEAM, WITH EXHAUST.

Even in cases where the temperature necessary is higher than that of steam at atmospheric pressure, it is not only possible but perfectly feasible to use the exhaust steam for bringing the temperature up to a certain point, and then to supplement by the use of live steam, thus making a great saving on what might otherwise be a very expensive operation.

In the dry-color works of the Chicago plant of the Sherwin-Williams Co., we have some good opportunities to make use of this principle. In some of the processes it is necessary for water in large quantities to be brought to the boiling point. This we have arranged to accomplish by drawing the water from a tank through which pass coils of pipe in connection with the exhaust steam heating system. If capacities are properly figured, the temperature of the water on leaving these tanks is close to 200° F., and it is only necessary to increase it from 12° to 15° by the use of live steam. If we assume that the average temperature of the cold water was 60° F., which is probably about correct, as, the water being supplied from artesian wells, the amount of live steam necessary to bring the water to the boiling point is only about 10% of what it would be were it heated entirely by the use of live steam.

DRYING OVENS.

Another instance of using exhaust steam supplemented by the use of live steam is in drying ovens where exhaust steam does not give a sufficiently high temperature to produce the desired results. In this case we bring air for drying into the ovens, passing it over coils connected to the exhaust-steam heating system. The temperature of the air is approximately 200° F. on entering the ovens. Live-steam coils are then placed in the ovens, located just as if no auxiliary heating had been done with exhaust steam. In this case, the percentage of saving is not so great as in the first, because the ultimate temperature desired is higher, but the saving in dollars runs into the thousands.

HEATING BUILDINGS.

The use of exhaust steam for heating buildings has come to be such a familiar thing with a great many engineers that they look upon it as a natural function of the steam-power plant; and yet, in figuring costs, it is very seldom taken into consideration.

In a paper presented by the writer at the [illegible] meeting of this Society in May, 1905, a system of power-plant accounting was described in which a method is used for determining the amount to be charged against departments and buildings for heating by exhaust steam, together with the consequent credit to be made to the power plant for this service. It is, of course, necessary, in order to arrive at the correct cost of steam power, to make the proper charges for it and all uses to which either live or exhaust steam may be put, and the corresponding credits back to the power plant give us the net cost of power.

CHARGE FOR HEATING.

The charge which we make to the different buildings and departments for the use of exhaust steam for heating is at the rate of 2 cents per month per sq. ft. of radiating surface for 6 months in the year. The charge for live steam which it is necessary to use for various purposes is generally determined by taking the amount of condensation for a certain period of time or for a certain operation, and then estimating the proportion of the total steam generated in the power plant which is being used in that department, and making a charge to the department each month for that proportion of the total cost of operating the boiler room. This amount includes the cost of coal delivered at the boiler, boiler room service, boiler room maintenance, insurance, supervision, and administration charges, removing ashes, etc.

RADIATION REQUIRED.

In figuring the radiation required in any building, when great accuracy is desired, the formula given by Professor Carpenter, of Cornell University, in his book "Heating and Ventilating Buildings," is generally used:

$$h = \left(\frac{n C}{55} + G + 1\tfrac{1}{4} W \right)$$

in which h = B. T. U. required per hr.,

C = contents of room in cu. ft.,

n = number of times air shall be changed for ventilation,

G = glass area in sq. ft.,

W = outside wall area in sq. ft.,

t = difference in temperature between the air in the room and outside.

However, for ordinary practical purposes, a rough calculation may be used. One sq. ft. of radiation for each 4 to 5 sq. ft. of floor space will be required for offices or rooms where persons are employed at sedentary occupations, while 1 sq. ft. of radiation for each 5 to 6 sq. ft. of floor space will be all that is required for factories and rooms where persons are employed at manual labor, and 1 sq. ft. of radiation for from 8 to 10 sq. ft. will be sufficient for warehouses, where the only heat necessary is enough to keep water pipes from freezing.

STEAM REQUIRED.

I find in practice that, on an average, when a full head of exhaust steam is maintained upon the radiators, about 250 heat units are radiated per hr. per sq. ft. of radiation. This amount is approximately correct as per Carpenter's tables, when the difference between the temperature of the radiator and the air in the room is 150° F. According to the same authority, the amount of steam condensed per hr. per sq. ft. of radiation would be about 0.25 lb., or, in other words, 1 lb. of steam would supply 4 sq. ft. of radiation.

I find in practice, however, that in using exhaust steam, 1 lb. will supply only about 3 sq. ft. of radiation. Assuming this amount to be correct, and that the engines in the power plant will consume 30 lbs. of steam per HP.-hr., then 1 HP. capacity in the power plant would furnish exhaust steam enough to heat 450 sq. ft. of offices, 600 sq. ft. in the factory, and 900 sq. ft. in the warehouse.

FUEL REQUIRED AND COST.

If we figure that 1 lb. of coal will produce 8 lbs. of steam, it will supply exhaust steam to about 25 sq. ft. of radiating surface for 1 hr., and if coal costs $2 a ton, the fuel necessary to supply 1 sq. ft. of radiation for 1 month, making proper allowances for the value of the steam used in the engine, will cost about 1 ct., assuming that we supply steam to the radiator for only about 10 or 12 hrs. per day.

Also, assuming that the amount of boiler room expenses will just about equal the fuel cost, we are justified in estimating our cost for exhaust steam at 2 cts. per sq. ft. per month during the months when heating is necessary. I do not believe that very many heating plants can be operated for heating alone, and supply live steam for this purpose, and get under a cost of 2 cents per sq. ft. per month.

After making the proper credit to the total cost of power generation for live and exhaust steam as outlined above, we have been able, in some of our plants, to produce electrical power at the switchboard for 1.5 cts. per KW.-hr. This, I believe, is better than can be done in any plant of the size we are operating by using gas engines, and particularly so when it is taken into

*Presented at Fifteenth Meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers.

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consideration that, if we used gas engines for power, it would be necessary to operate a boiler plant to generate steam for heating, and for the many other purposes to which we put it.

USE OF COMPOUND ENGINES.

There are great possibilities along the line of using high-pressure compound engines for power which can be operated either condensing or non-condensing, so that they can be run condensing in the summer time, or whenever the exhaust steam is not needed for heating, and operated non-condensing the balance of the time.

We recently installed a 300-HP. Westinghouse compound engine in our Newark factory, to be run on 150 lbs. steam pressure, non-condensing. This is now operating on an average of about 23 lbs. of steam per HP.-hr. The idea in this is all right as far as it goes, but I consider that a later installation which we have just made, of a 300-HP. compound engine in our Chicago factory, which can be run non-condensing when we need exhaust steam and condensing when we do not need the steam, is a step still further in advance.

HEATING FROM GAS ENGINES.

So far we have given no credit to the gas engine for the possibility of using the heat of the exhaust gases for heating buildings. That there is such a possibility cannot be denied, but it is limited because, first, of the low fuel-consumption of the gas engine per HP.-hr., and, second, the large percentage of the heat units contained in the fuel which are converted into power. In a simple non-condensing steam engine using 30 lbs. of steam, there are about 30,000 heat units contained in the exhaust steam for each HP.-hr., and this would supply about 90 sq. ft. of radiation after due allowance for losses in the supply pipes, steam for heating feed water, etc., had been deducted.

The waste heat in exhaust gases from the average gas engine would contain about 6,000 heat units per HP.-hr., which would be available for use in heating, and would supply only about 20 sq. ft. of radiation, after due allowance for losses. About half of this heat would be contained in the jacket water, and probably the easiest way to utilize the total heat available would be to put the exhaust gases through a tubular heater, and combine the jacket water with the water from this heater in a hot-water heating system. I have seen accounts of a number of gas-engine plants where hot jacket-water has been used for heating, and I believe that there are a few instances where the heat of exhaust gases has been still further utilized by heaters as outlined above: but the possibilities of any extensive heating systems being installed along these lines are, no doubt, limited.

COMPARATIVE COSTS OF GASOLINE, GAS, STEAM AND ELECTRICITY FOR SMALL POWERS.

By WILLIAM O. WEBBER,* M. Am. Soc. M. E.

The comparative cost of the various sources of power is a matter of very great interest in installations of small power where any one is equally available and the sole determining factor is expense. Particularly is a determination of these costs necessary in the many cases now coming up where the enforcing of rigid river pollution laws makes necessary a change in the numerous small water-power plants along rivers contributing to the water supply of nearby cities. In the usual determination of these relative costs it has been assumed that the total cost of a new plant was merely the cost of the machine plus the cost of the material required to run it, and that the additional cost of depreciation, interest, insurance, etc., would be the same in each instance. It is also generally assumed that the power costs just so much per horse-power regardless of the amount used. These are both very erroneous impressions.

The following tables give the itemized cost of 1 HP. per hour on 2, 6, 10 and 20-HP. plants respectively for gasoline, gas, steam and electric power.

Table I. shows the cost of gasoline power, and is based on fact, not theory. All gasoline engines do not run on one-eighth of a gallon of gasoline per brake horse-power per hour, and to get at fair comparative results, proper allowances must be made for depreciation, repairs and insurance, as well as taxes, and the room occupied by the plant must be taken into account.

Table II. shows the costs for the same powers driven by electricity. It will be noted that proper allowance must be made for attendance, although this item is not generally charged as it should be. In this case nothing is charged for room, as separate power rooms are not required.

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TABLE I.—COST OF GASOLINE POWER.

Size of plant in HP.	2	6	10	20
Price of engine in place	$150.00	$325.00	$500.00	$750.00
Gasoline per B. HP. per hour	½ gal.	⅓ gal.	¼ gal.	¼ gal.
Cost per gallon	$0.22	$0.20	$0.19	$0.18
=cost per 3,080 hrs.	$451.53	$924.00	$975.13	$1,386.00
Attendance at $1 per day	308.00	308.00	308.00	308.00
Interest, 5%	7.50	16.25	25.00	37.50
Depreciation, 5%	7.50	16.25	25.00	37.50
Repairs, 10%	15.00	32.50	50.00	75.00
Supplies, 20%	30.00	65.00	100.00	150.00
Insurance, 2%	3.00	6.50	10.00	15.00
Taxes, 1%	1.50	3.25	5.00	7.50
Power cost	$824.03	$1,371.75	$1,498.13	$2,016.50
To these figures should be added charges on space occupied, as follows:				
Value of space occupied	$100.00	$150.00	$200.00	$300.00
Interest, 5%	$5.00	$7.50	$10.00	$15.00
Repairs, 2%	2.00	3.00	4.00	6.00
Insurance, 1%	1.00	1.50	2.00	3.00
Taxes, 1%	1.00	1.50	2.00	3.00
Total annual charge for space	$9.00	$13.50	$18.00	$27.00
Total cost per annum	$833.03	$1,385.25	$1,516.13	$2,043.50
Cost of 1 HP. per annum 10 hr. basis	416.51	239.87	151.61	102.17
Cost of 1 HP. per hour	$0.1352	$0.0780	$0.0492	$0.0331

The costs for the electric current which are used in Table II. are figured from the discount table shown as follows:

COSTS OF ELECTRIC CURRENT.

Base Price = 13½ cts. per KW.-hour. Discounts on Monthly Bill.

Monthly bill.	Discounts.	Monthly bill.	Discounts.
$5	10%	$100 to $125	40%
$10 to $20	15%	$125 to $150	45%
$20 to $25	20%	$150 to $175	50%
$25 to $50	25%	$175 to $200	55%
$50 to $75	30%	$200 to $500	60%
$75 to $100	35%	$500 & over	65%

For 2 HP. plant:

$$\frac{3{,}080 \text{ hrs.} \times 2 \text{ HP.} \times 0.746}{82\% \text{ Effic.}} = 5{,}604.10 \text{ KW.-hr. per annum}$$

then 5,604.1 × $0.135 = $756.55, Ann. cost without disc't.
Monthly bill = $63. Disc't = 30%.
$756.55 × 70% = $529.56 = Annual cost.

For 6 HP. plant:

$$\frac{3{,}080 \text{ hrs.} \times 6 \text{ HP.} \times 0.746 \times \$0.135 \times 45\%}{80\% \text{ Efficiency}} = \ldots\ldots \$976.00$$

Monthly cost = $180. Disc't = 55%.

For 10 HP. plant:

$$\frac{3{,}080 \times 10 \times 0.746 \times 0.135 \times 40\%}{87\%} = \ldots\ldots\ldots\ldots \$1{,}425.00$$

Monthly cost = $298. Disc't = 60%.

For 20 HP. plant:

$$\frac{3{,}080 \times 20 \times 0.746 \times 0.135 \times 35\%}{88.5\%} = \ldots\ldots\ldots\ldots \$2{,}450.00$$

Monthly cost = $585. Disc't = 65%.

Table III. gives the cost of gas power, using illuminating gas of 760 B. T. U. No estimate is made on the cost of gas power, using producer gas, as it would not pay to put in a gas producer for so small a unit.

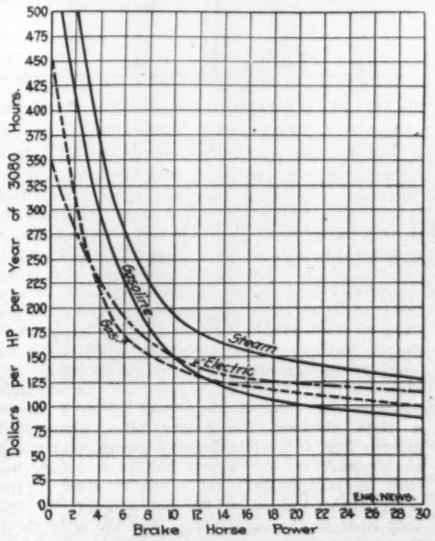


Diagram Showing Comparative Costs per Brake Horse-Power of Steam, Electricity, Gas and Gasoline in Small Powers.

TABLE II.—COST OF ELECTRIC POWER.

Size of plant in HP.	2	6	10	20
Cost of motor in place	$83.00	$118.00	$216.00	$270.00
With wiring, etc.	100.00	130.00	240.00	300.00
Cost of electricity 3,080 hrs.	$529.56	$976.00	$1,425.00	$2,450.00
Attendance	20.00	30.00	50.00	50.00
Interest, 5%	5.00	6.50	12.00	15.00
Depreciation 10%	10.00	13.00	24.00	30.00
Repairs, 5%	5.00	6.50	12.00	15.00
Supplies, 1%	1.00	1.30	2.40	3.00
Insurance, 2%	2.00	2.60	4.80	6.00
Taxes, 1%	1.00	1.30	2.40	3.00
Total cost per annum	$573.56	$1,037.20	$1,532.00	$2,572.00
Cost of 1 HP. per annum, 10hr. basis	286.78	172.86	153.20	128.60
Cost of 1 HP. per hour	$0.0928	$0.0558	$0.0497	$0.0417

TABLE III.—COST OF GAS POWER.

$1.50 per 1,000 cu. ft. of gas less 20%, if paid in 10 days = $1.20 net, gas 760 B. T. U.

Size of plant in HP.	2	6	10	20
Engine cost if in place	$200.00	$375.00	$550.00	$1,050.00
Gas per HP.-hour in ft.	30	25	22	20
Value of gas consumed, 3,080 hrs.	$221.76	$554.40	$843.12	$1,478.00
Attendance, $1 per day	308.00	308.00	308.00	308.00
Interest, 5%	10.00	18.75	27.50	52.50
Depreciation, 5%	10.00	18.75	27.50	52.50
Repairs, 10%	20.00	37.50	55.00	105.00
Supplies, 20%	40.00	75.00	110.00	210.00
Insurance, 2%	4.00	7.50	11.00	21.00
Taxes, 1%	2.00	3.75	5.50	10.50
Power cost	$615.76	$1,023.65	$1,387.62	$2,237.50
Annual charge for space	9.00	13.50	18.00	27.00
Total cost per annum	$624.76	$1,037.15	$1,405.62	$2,264.50
Cost of 1 HP per annum, 10 hr. basis	312.38	172.86	140.56	113.22
Cost of 1 HP. per hour	$0 1014	$0.0561	$0.0456	$0.0367

TABLE IV.—COST OF STEAM POWER.

Size of plant in HP.	6	10	20
Cost of plant per HP.	$250.00	$220.00	$200.00
Fixed charge, 14%	$35.00	$30.80	$28.00
Coal per HP.-hour, in lbs.	20	15	12
Cost of coal at $5 per ton	$154.00	$103.00	$82.50
Attendance, 3,080 hours	75.00	50.00	30.00
Oil waste and supplies	15.00	10.00	6.00
Cost 1 HP per ann., 10 h. basis=	$279.00	$194.80	$146.50
Cost of 1 HP per hour	$0.0906	$0.0632	$0.0475

TABLE V.—ANNUAL COST OF POWER PER BRAKE-HORSE-POWER.*

B. HP. of unit.	Steam.	Electricity.	Gas.	Gasoline.
1	$480.00	$312.50	$390.00	$487.50
2	360.00	282.00	312.50	416.00
3	337.50	252.00	260.00	350.00
4	375.00	227.50	220.00	300.00
5	320.00	207.50	192.50	262.50
6	280.00	192.00	172.50	240.00
7	250.00	179.00	160.00	210.00
8	230.00	168.00	152.50	182.50
9	210.00	158.00	145.00	165.00
10	195.00	152.00	140.00	152.00
12	175.00	140.00	132.50	137.50
14	165.00	133.00	126.00	122.00
16	157.50	128.00	120.00	112.50
18	150.00	126.00	116.50	107.50
20	146.00	123.00	113.00	102.00
22	140.00	121.50	110.00	98.00
24	137.50	119.50	107.50	95.00
26	133.00	117.50	105.00	92.50
28	130.00	116.50	102.50	90.00
30	127.50	115.00	102.00	87.50
35	124.00	113.50	100.00	85.00
40	120.00	112.00	98.00	82.50
50	112.50	110.00	96.00	80.00
60	105.00	108.00	94.00	78.00
70	100.00	106.00	92.00	76.00
80	95.00	104.00	90.00	74.00
90	90.50	102.00	88.00	72.00
100	86.40	100.00	86.00	70.00

*Unit costs = Coal, $5 per ton; electricity, $0.135 per KW.-hour; gas, $1.20 per 1,000 ft., at 760 B. T. U.; gasoline, $0.20 per gallon.

In Table IV. are given figures on the cost of steam power, from 6 to 20 HP., but no estimate is made on the cost for 2 HP., for the reason that such a plant would be too small to consider.

The curves shown in the accompanying diagram are the average curves for the four different powers plotted from the figures given in Tables I.-IV. The values do not always agree with those shown in the tables owing to the necessity of making the curve which most nearly approaches all values given. The figures in Table V. are taken from curves in the diagram.

A PILE TRESTLE ERECTED WITH A PIVOTAL PILE-DRIVER.

By R. BALFOUR.*

In localities where durable pile material of sufficient length can be readily procured, the pile trestle is often the most economical way of carrying a roadway over a depression in the ground, even if that depression should be as much as 60 ft. In fact the height of the pile trestle is only limited by the length of suitable materials procurable. The minimum diameter of such piles at the small end should be not less than 12 ins., and the piles should be driven with the butt end down. Where hard material is encountered, of course it would be necessary to hew down the butt end of the pile to facilitate its entrance into the ground. Great care must be exercised in driving piles butt down not only on account of the smaller area of the driving end but also because the upper part of the tree trunk is always of a more tender fiber than the lower. For that reason it is best to use a very heavy hammer from 3,500 to 6,000 lbs. Many short blows with a hammer like this will drive a pile more satisfactorily than the long drop of a lighter hammer. The long drop is very destructive to the pile, whereas with the drop of the heavy hammer a pile may be driven much firmer without any apparent abrasion of the upper end. Where straight piles can be procured, this style of structure has a very neat and workmanlike appearance.

This design is an admirable one where the bridge is intended to be filled in by trains, as the lower end of the sway braces can be cut out and removed before very much filling is done. So also when the filling comes up to the bottom of the longitudinal and cross-wales they can be removed so that after the structure is filled in there is nothing in the filling except the upright posts with their large ends down. No cross-wales, sway braces or longitudinal wales are left to hold up the material and leave voids which will continue for a very long time and cause settling of the embankment.

The writer has made application for United States patent for the pivotal pile-driver shown in Figs. 1-2. This pile-driver is moved forward to its proper position on rollers, which are placed on top of the caps already in place, then the swinging leads are swung over to one side and held in position there by convenient methods. The pile is driven and the leads are allowed to drop down to the next pile; that pile is driven and the process repeated until all the piles are down. The piles are then cut off and the cap put in place; a certain amount of sway bracing and cross-waling, and in some cases longitudinal wales are put on. A pair of rollers are placed on the last cap, and the machine moved forward for the next bent.

It will be noticed that there is no lateral motion to the framework of the pile-driving machine. The framework is of such a height that when the leads are swung to the proper position for the upper end of the pile under the cap the pile has the batter required, thus avoiding one movement which is invariably required in any other pile-driver.

A smart pile-driver crew, where the piles are straight and the ground does not present very many difficulties, should put in four bents per day of ten hours, and in some cases they might put in six bents, and if a few extra men were employed to snugup the bracing of bents and allow the pile-drivers to proceed under temporary bracing, or even to use guy lines to high bents and use temporary longitudinals, they might do as much as eight bents in ten hours. Where the pile has considerable penetration, this pile-driving machine can be run over the piles without their being braced and ten or twelve, or even more, bents per day of ten hours can be driven over muskegs, lagoons, lakes and shallow but not too swift rivers.

When driving very heavy piles the engine might not be quite heavy enough to counterbalance the weight of one of those piles; in that case it would be well to rig on the rear end of the machine lines with hooks on their ends. These could be dropped under the cap immediately below the rear end of the driver and hauled taut so there would be no danger of displacement of the pile driving machine. The rollers on which the machine is to be operated are not very well shown in the drawing submitted. They should be equipped with some means of dogging them when the machine had been moved to its proper place. This is an easy matter and can be readily accomplished.

Where time is not the first consideration, these structures can be readily built by an over-reach pile-driver, such as is shown in Figs. 1 and 2. If great speed is required, a pile-driver like the one illustrated in Figs. 3-5 should be used. This will enable the piles to be driven without interfering with the carpenters, and 100 piles can be driven per 24 hours with each pile-driver. The same views show a portion of a pile structure 60 ft. in height which with a slight modification is a model in its way. The slight modification is that all of the piles should be driven with large end down, the same as the batter piles shown in the half-tones. This structure is a trestle on the Crow's Nest Pass Branch of the Canadian Pacific Railway. The bridge was about 3,600 ft. long, having two Howe truss spans of 150 ft. each on pile piers, the balance of the distance being constructed of pile bents. Fig. 3 shows a vista through the batter piles when first driven; Fig. 4 the pile-driver at work, and Fig. 5 an immense ice shove that hit the structure before its completion. It is the opinion of the writer that the extra flexural strength of the butt ends of the batter piles was the only thing that saved this trestle and that it surely would have gone out had these outside piles been driven point down as is usual in such cases.

*38 Somerset Street, Ottawa.

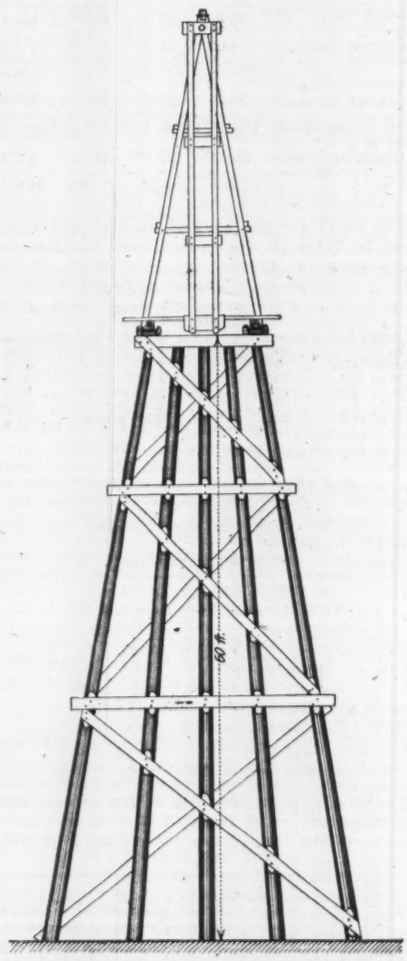


Fig. 1. Front Elevation of Pivotal Pile Driver for Driving Piles at Any Angle.

THE INTERCEPTING SEWER SYSTEM of Chicago is completed as far as the South Side is concerned, and is now in full operation. The pumps at the 39th St. pumping station have been in operation since the latter part of December, 1905, and since that time all the sewage on the South Side has been going into the lake north of 87th St. Preparations are now being made for the official test of this plant. This pumping station is on the lake front and delivers sewage and lake water to a 6-ft. conduit extending beneath 39th St. to the south branch of the Chicago River. On the north side, the service will be taken care of some time before the end of this year, the land section of the 16-ft. Lawrence Ave. conduit being nearly completed. This conduit will deliver sewage and lake water into the north branch of the Chicago River, but owing to delays and the cancellation of the contract with J. P. Agnew for the intake tunnel, it will probably be a year before lake water can be pumped. The contractors for the intake and the crib are prosecuting their work as the weather permits. The pumping station is at the river end of the tunnel; the centrifugal pump and the boilers have been installed, and the screw pump is now being erected. The Allis-Chalmers Co. has the contract for the pumping plant, and the Edge Moor Iron Co. has that for the boilers. Some years of delay in the construction of the Lawrence Ave. conduit were caused by the failure of the original contractors and litigation over the city's decision to complete the work by day labor. The courts held that the city must let contracts for the work, and the land section has now been completed by H. M. McGovern. Some additional delay in completing the land section of this sewer tunnel will be caused by the fact that the eastern end (constructed in 1898) is found to be 6 ft. off the line. This was only recently discovered, when the western section was completed, and will necessitate some additional work to avoid a sharp bend in the tunnel. The responsibility for the error has not been placed, and the engineer who was in charge of the earlier work is now dead. The work is being done under the direction of Mr. John Ericson, City Engineer; and Mr. Wm. S. MacHarg is Consulting Engineer for the intercepting sewer division of the Bureau of Engineering. The intercepting sewer system as a whole was described and illustrated in our issue of May 28, 1903, and its relation to the city's sewerage, drainage and water supply system was discussed in our issue of Nov. 9, 1905.

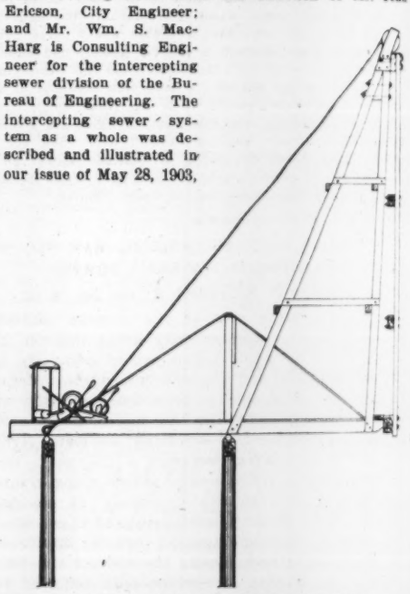


Fig. 2. Side View of Pivotal Pile Driver.

A DOUBLE-ADHESION LOCOMOTIVE, designed to use large driving wheels in ordinary running and smaller wheels when ascending grades, has been invented by Mr. G. A. Bothwell, of Owen Sound, Ont., Canada, and an eight-wheel (4-4-0) engine has been converted to this system by the Hicks Locomtive & Car Works, of Chicago. The smaller wheels are placed behind the larger wheels, and are driven by connecting rods attached to the coupling rod of the larger wheels; normally they revolve idly. By means of a system of levers operated from a steam cylinder the smaller wheels are forced upon the rails, while the larger ones are lifted clear of the rails. If desired, the tender axles can be driven by bevel gears. The experimental engine has cylinders 17 × 24 ins., 60-in. main driving wheels and 32-in. auxiliary wheels; the weight is 54 tons (6 tons due to the special mechanism), with 36 tons on the driving wheels. The tractive effort is normally 12,948 lbs., and can be increased to 24,276 lbs. It is stated that in a test the engine stalled on a grade with a train of 25 cars, but that with the small driving wheels in use it ascended the same grade with 45 cars.

GENERAL CONCLUSIONS OF THE MUNICIPAL OWNERSHIP COMMITTEE OF THE NATIONAL CIVIC FEDERATION.

For some two years a committee of the National Civic Federation assisted by various engineers and accountants, has been making an investigation of municipal ownership of gas and water-works, electric light and power plants, and street railways. Altogether, 29 private and public plants in the United States and 24 in Great Britain were examined. A general outline of the character of the investigation, with the names and addresses of the members of the Committee and of the engineers, was published in our issue of Oct. 4, 1906. The report of the Committee, in three large volumes, will soon be ready for distribution.* A summary of the general conclusions of the Commission has been distributed to the members in advance of the publication of the report. The greater part of this summary is given below.

Twenty men in widely different walks of life joined in the report.†. Of these, 19 signed the report, but two, as stated in our foot-note, dissented from many of its most important conclusions. The 20th member found himself in agreement with practically nothing in the report signed by the 19, and submitted his views separately. In introducing the summary of the Committee's conclusions, the Secretary, Mr. Moffett, made some general statements which we condense as follows:

It is difficult to give positive answers of universal application to the questions arising as to the success or failure of municipal ownership as compared with private ownership. The local conditions affecting particular plants are in many cases so peculiar as to make a satisfactory comparison impossible, and it is very difficult to estimate the allowance that should be made for these local conditions.

Further, the difficulty of reaching satisfactory results by the comparative method is not confined to special or local conditions. It is true, as well, of much broader questions. Thus any attempt to compare municipal with private electric light plants in the United States would be fruitless if allowance were not made for the fact that in most cases such municipal plants are confined to street lighting and may not do commercial business. Allowance must be made also for the fact that many municipal plants have had a struggle to exist in the face of unsympathetic public opinion. Again, in England consideration must be given to the fact that the municipal electric light and street railway plants have permanent rights, while the rights of the private companies operating these particular utilities are limited as to the length of their existence, many street railway franchises expiring 21 years after they were granted.

Finally, not only must it be borne in mind that the social and political conditions which characterize the two countries find expression in their private and public systems, but we must consider the difference in the nature of the two peoples which causes them to adopt different ideas and views as to the expediency of certain things. In other words, a measure of success in the municipal management of public utilities in England should not be regarded as necessarily indicating that the municipal management of the same utilities in this country would be followed by a like measure of success. Conditions are quite different in the two countries.

For convenience and clearness in showing points of divergence of the two members who dissented from the report which they, with the other 17, signed, we have inserted their points of dissent at the proper places in our quotation of the general summary. These dissents are printed in italics and are included in brackets. The main summary follows:

FIG. 3. BATTER PILES DRIVEN BUTT END DOWN; ST. MARY'S BRIDGE, CANADIAN PACIFIC RY.

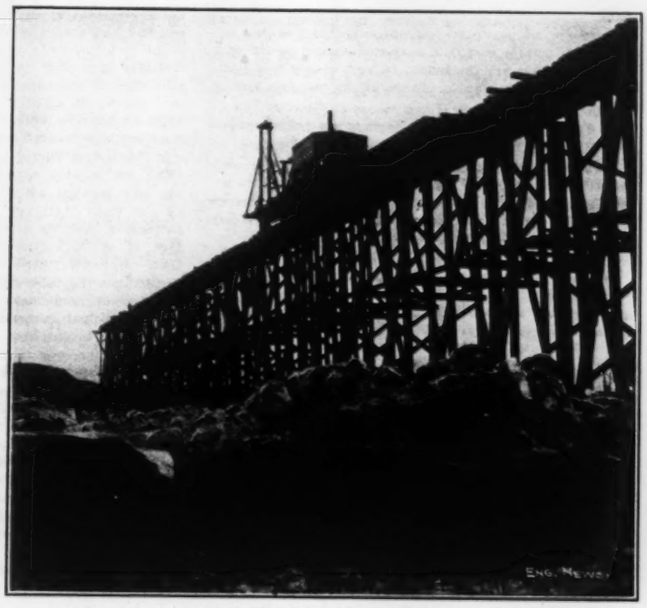


FIG. 5. ICE SHOVED AGAINST PILE TRESTLE ON CANADIAN PACIFIC RY.

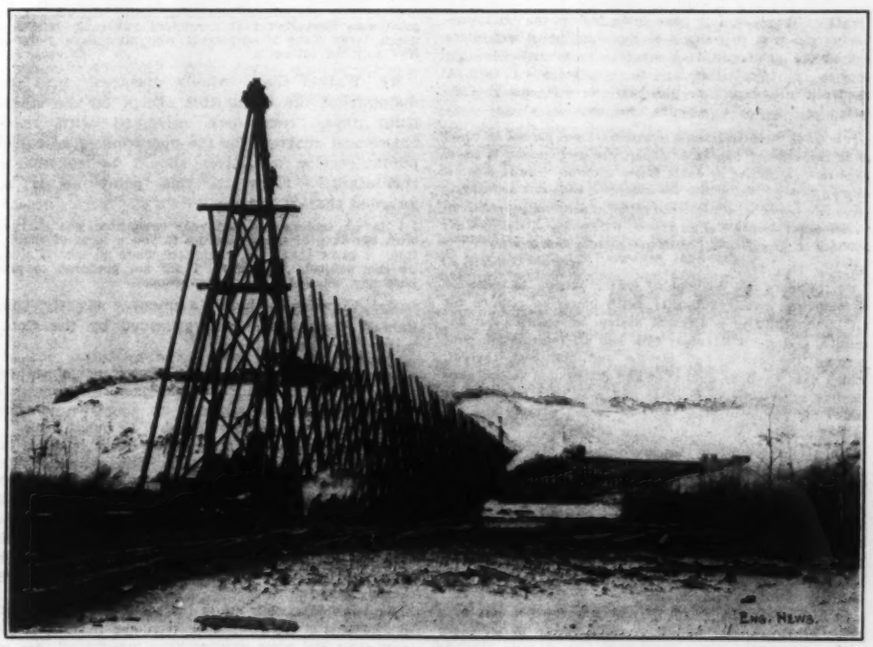


FIG. 4. BATTER PILE DRIVER AT WORK ON ST. MARY'S BRIDGE, CANADA.

*Address E. A. Moffett, Secretary, Municipal Ownership Committee, National Civic Federation, 281 Fourth Ave., New York City, for circular describing the report and stating the terms under which it may be obtained.

†19 of the 20 members participating in the report signed the general report, as follows: Chairman, Melville E. Ingalls, Chairman Board of Directors Big Four Railroad, Cincinnati, Ohio; Vice-Chairman, Dr. Albert Shaw, Editor "Review of Reviews," New York City; Secretary, Edward A. Moffett, Editor "Bricklayer and Mason," Indianapolis, Ind.; Edward W. Bemis, Superintendent of Water-Works, Cleveland, O.; William J. Clark, General Manager of the foreign department of the General Electric Co., New York City; Prof. John R. Commons, University of Wisconsin, Madison, Wis.; Charles L. Edgar, President of the Edison Electric & Illuminating Co., Boston, Mass.; Walter L. Fisher, President of the Municipal Voters' League, Chicago, Ill.; Prof. Frank J. Goodnow, Columbia University, New York City; Prof. John H. Gray, Northwestern University, Evanston, Ill.; Timothy Healy, President of the International Brotherhood of Stationary Firemen, New York City; Daniel J. Keefe, President of the International Longshoremen's Association, Detroit, Mich.; Milo R. Maltbie, member of the new Public Service Commission for Greater New York; H. B. F. Macfarland, President of the Board of Commissioners of the District of Columbia, Washington, D. C.; Frank J. McNulty, President of the International Brotherhood of Electrical Workers, Springfield, Ill.; Prof. Frank Parsons, President of the National Public Ownership League, Boston, Mass.; J. W. Sullivan, Editor "Clothing Trades Bulletin," New York City; Talcott Williams, editorial writer of the "Press," Philadelphia, Pa., and Albert E. Winchester, Superintendent of the South Norwalk, Conn., Electric Works. Messrs. Wm. J. Clark, and Chas. L. Edgar dissented from the report in some particulars, and the 20th member, Mr. Walton Clark, Vice-President of the United Gas Improvement Co., of Philadelphia, submitted a minority report, as stated at more length in our article.

There are some general principles which we wish to present as practically the unanimous sentiment of our committee.

First, we wish to emphasize the fact that the public utilities studied are so constituted that it is impossible for them to be regulated by competition. Therefore, they must be controlled and regulated by the government; or they must be left to do as they please; or they must be operated by the public. There is no other course. None of us is in favor of leaving them to their own will, and the question is whether it is better to regulate or to operate.

There are no particular reasons why the financial results from private or public operation should be different if the conditions are the same. In each case it is a question of the proper man in charge of the business and of local conditions.

[We dissent from the implication in this paragraph that the conditions are or are likely to be the same.—Edgar and Clark, W. J.]

We are of the opinion that a public utility which concerns the health of the citizens should not be left to individuals, where the temptation of profit might produce disastrous results, and therefore it is our judgment that undertakings in which the sanitary motive largely enters should be operated by the public.

[We dissent from this conclusion as having been proved by our investigation. In our opinion, privately operated water systems were, especially as regards their consideration for the public health, as properly and successfully managed as the publicly operated water systems.

—Edgar and Clark, W. J.]

We have come to the conclusion that municipal ownership of public utilities should not be extended to revenue-producing industries which do not involve the public health, the public safety, public transportation, or the permanent occupation of public streets or grounds, and that municipal operation should not be undertaken solely for profit.

[This sentence is so drawn that to a casual reader it implies that the opposite is advisable. From this we strongly dissent

—Edgar and Clark, W. J.]

We are also of the opinion that all future grants to private companies for the construction and operation of public utilities should be terminable after a certain fixed period, and that meanwhile cities should have the right to purchase the property for operation, lease or sale, paying its fair value.

To carry out these recommendations effectively and to protect the rights of the people, we recommend that the various states should give to their municipalities the authority, upon popular vote under reasonable regulations, to build and operate public utilities, or to build and lease the same, or to take over works already constructed. In no other way can the people be put upon a fair trading basis and obtain from the individual companies such rights as they ought to have. We believe that this provision will tend to make it to the enlightened self-interest of the public utility companies to furnish adequate service upon fair terms, and to this extent will tend to render it unnecessary for the public to take over the existing utilities or to acquire new ones.

[The words "under reasonable regulations" were put into the report at the suggestion of Charles L. Edgar, and were intended by him to mean such regulations as would compel deliberate consideration not only by the people, but by their representatives, and would consequently prevent the superficial attractiveness of the scheme from overriding the "sober second thought" of the people. We strongly dissent from any definition of "regulations" which does not cover these points.

—Edgar and Clark, W. J.]

Furthermore, we recommend that provision be made for a competent public authority, with power to require for all public utilities a uniform system of records and accounts, giving all financial data and all information concerning the quality of service and the cost thereof, which data shall be published and distributed to the public like other official reports; and also that no stock or bonds for public utilities shall be issued without the approval of some competent public authority.

We also recommend the consideration of "the sliding scale," which has proved successful in some cases in England with reference to gas and has been adopted in Boston. By this plan the authorized capitalization is settled by official investigation, and a standard rate of dividend is fixed, which may be increased only when the price of gas has been reduced. The subway contracts and their operation in Boston and New York are also entitled to full consideration.

In case the management of public utilities is left with private companies, the public should retain in all cases an interest in the growth and profits of the future, either by a share of the profits or a reduction of the charges, the latter being preferable, as it inures to the benefit of those who use the utilities, while a share of the profits benefits the taxpayers.

Our investigations teach us that no municipal operation is likely to be highly successful that does not provide for:

(1) An executive manager with full responsibility, holding his position during good behavior.

(2) Exclusion of political influence and personal favoritism from the management of the undertaking.

(3) Separation of the finances of the undertaking from those of the rest of the city.

(4) Exemption from the debt-limit of the necessary bond issues for revenue-producing utilities, which shall be a first charge upon the property and revenues of such undertaking.

We wish to bring to your consideration the danger here in the United States of turning over these public utilities to the present government of some of our cities. Some, we know, are well governed and the situation on the whole seems to be improving, but they are not up to the government of British cities. We found in England and Scotland a high type of municipal government, which is the result of many years of struggle and improvement. Business men seem to take a pride in serving as city councilors or aldermen, and the government of such cities as Glasgow, Manchester, Birmingham and others includes many of the best citizens of the city. These conditions are distinctly favorable to municipal operation.

In the United States, as is well known, there are many cities not in such a favorable condition. It is charged that the political activity of public service corporations has in many instances been responsible for the unwillingness or inability of American cities to secure a higher type of public service. This charge we believe to be true. However, there seems to be an idea with many people that the mere taking by the city of all its public utilities for municipal operation will at once result in ideal municipal government through the very necessity of putting honest and competent citizens in charge. While an increase in the number and importance of municipal functions may have a tendency to induce men of a higher type to become public officials, we do not believe that this of itself will accomplish municipal reform. We are unable to recommend municipal ownership as a political panacea.

In many cases in the United States the people have heedlessly given away their rights and reserved no sufficient power of control or regulation, and we believe that corruption of public servants has sprung, in large measure, from this condition of things. With the regulations that we have advised, with the publication of accounts and records and systematic control, the danger of the corruption of public officials is very much reduced.

Continuing along the same general line as some of Mr. Moffett's remarks given above, regarding the bearing that local conditions have upon municipal ownership, the Committee says:

What may be possible in one locality may not be in another. In some cities the companies may so serve the public as to create no dissatisfaction, and nothing might be gained by experimenting with municipal ownership. Again, the government of one city may be good and capable of taking charge of these public utilities, while in another it may be the reverse. In either case the people must remember that it requires a large class of able men as city officials to look after these matters. They must also remember that municipal ownership will create a large class of employees who may have more or less political influence.

Mr. Walton Clark wholly disagrees with the majority of the Committee except on the single point that "companies entrusted with franchises and charters for the operation of so-called public service industries should be subject to regulation." Even on this point he is so guarded that he states:

I do not understand that your committee was charged with the duty of recommending to you a form of regulation. I know that your committee made no special study on this subject. Therefore, I am not prepared to propose any detailed plan of regulation.

Mr. Clark's further statements, slightly condensed from the summary issued by the Committee, are as follows:

Recognizing the almost supreme importance of an adequate and cheap supply of pure water, I dissent from one of the recommendations of my associates, in effect that water-works should be operated by public bodies. I dissent for the reason that my study of the report of the water-works expert employed by your committee, and my personal investigations, lead me to the conclusion that the water companies have made the more intelligent efforts toward adequacy and purity of supply, and that, all conditions considered, the result of their efforts has been and is a better and cheaper water supply and service than that maintained by the municipal water-works departments.

My knowledge leads me to the conclusion that the city and citizens of Glasgow, Manchester and Birmingham, as well as of the other municipalities investigated, are not so well served by their public service trading departments as the cities and citizens of London, Newcastle, Sheffield, Dublin and Norwich are by companies operating similar trading industries, and that there is no element of blessing in the municipalization in the former cities to compensate for the indifferent character of the service rendered.

I cannot believe that the prescribed remedy for any ill should be a worse ill, and I cannot recommend that a municipality suffering, or believing that it suffers, under public administration of a public utility, should be given the right to engage in the operation of such utility for itself, without such a course of procedure as will make sure that the sober second thought of the people shall have ample opportunity for development and expression before the community is committed to municipal ownership with the accompanying dangers and difficulties, which you are warned in the majority report.

Because I believe that the general credit of municipalities should be conserved for the benefit of public and necessary improvements, from which, in the nature of things, private enterprise is excluded; and because I believe that a municipality should not in any event engage in any trading enterprise that will not pay its own way, and have the confidence of the citizens as financially sound; I think that municipalities should be prohibited by statute from making investments in trading operations, except with money borrowed on mortgage, or otherwise, the loan being secured by a lien on the plant in which it is invested, and on the right to operate the same, and on this only.

[Mr. Clark dissents (to quote the language of the official summary of the report) from the opinion that a city should have the right to purchase at its option the property of public service corporations for operation, lease or sale. He bases his opposition on the belief that it is practically impossible to secure private funds for investment in an enterprise subject to purchase by a municipality, at any date to be selected by the municipality, and because he believes that the impossibility of so securing private investment may, and often will, work a social harm to a community.]

I am convinced that the condition of the British people, individually or collectively, has not been improved by the municipalization of the industries we have investigated.

I believe that political and social conditions in the United States are less favorable to the success of municipal ownership than are the same conditions in Great Britain.

I find this conclusion strengthened by our investigation into municipalized industries in the United States.

I am convinced that, under American conditions, the system of private ownership of public utilities is best for the citizens and the consumers.

I recommend state regulation and protection of public service companies, provided by statute, and as far as possible automatic in its application and operation.

WORK AT THE MADELEINE SEWAGE EXPERIMENT STATION, PASTEUR INSTITUTE OF LILLE, FRANCE.*

By EARLE B. PHELPS.†

France has been regrettably backward in protecting her streams from pollution. The experiment station at Madeleine was established by the Pasteur Institute of Lille as the result of a popular agitation for more stringent regulation against stream pollution. The movement took definite form in the organization of a "consortium de propriétaires et de communes," with which was associated the National Association of Fishermen. Under the presidency of M. Ory, propriétaire of Lambersart, near Lille, and also president of the Fishermen's Association, a vigorous campaign was organized for the protection of the grossly polluted rivers of the Nord district: the Deule, Marque and Lys. Realizing at the outset that it was first of all necessary to indicate to the authorities and private interests concerned the most practical methods for the disposal of their wastes, the "consortium" asked the Pasteur Institute to undertake a study of the various methods in use for the disposal of sewage and industrial wastes. Financial support was granted the enterprise by the National Bureau of Scientific Research, of the Ministry of Public Instruction, and an experiment station was established at Madeleine, a suburb of Lille, on the Deule River. The work was started in July, 1904, under the direction of Dr. A. Calmette, corresponding member of the Pasteur Institute and of the Academy of Medicine, with the cooperation of Messrs. E. Rolants, E. Boullanger, F. Constant and L. Massol, all of the Institute, and, during the first year, of Prof. A. Buisine, Director of the Institute of Chemistry of the Faculty of Sciences of Lille.

DESCRIPTION OF THE PLANT.—A rectangular flume conducts the sewage by gravity from the main interceptor of Madeleine to the works. Here it enters a regulating chamber which is so devised that the flow can never exceed the rate of 500 cu. m. (123,000 gals.) per 24

*Based on two French reports, entitled "Recherches sur L'Epuration Biologique et Chemique des Eaux d'Egout," noticed in our Engineering Literature Supplement of this week.

†Sanitary Research Laboratory, Massachusetts Institute of Technology, 786 Albany St., Boston, Mass.

hours. During the night the rate of flow is much less. After passing a screen of iron bars with openings of 6 cm. (2.3 ins.), and a sampling chamber ingeniously devised so that at all times one-fifth of the total flow is bye-passed to a sampling reservoir for analysis and measurement, the main stream is divided into two parts and passes through two grit chambers to the two septic tanks. The settling basins have a capacity of 2 cu. m. (515 gals.) each, and permit the sedimentation of mineral and other non-putrescible matter. They are cleaned weekly. The septic tanks are identical in all respects except that one is covered. They are each 33 m. (108 ft.) in length, 3 m. (9.7 ft.) in width and 2.61 m. (8.55 ft.) in depth, with a water capacity of 250 cu. m. (64,000 gals.). Each tank is provided with four baffles; one alternate pair extending from the surface to within 60 cm. (23.5 ins.) of the bottom, the other pair from the bottom to within 60 cm. of the top. They are also provided with thermometers and the closed tank with cocks for the removal of gas for analysis. The tank effluents, after passing through another sampling chamber by which exactly 1/100 of the total flow is diverted and collected for analysis, go to a common collecting reservoir of 50 cu. m. (12,800 gals.) capacity, whence they are discharged when desired upon the filters.

During the first 15 months of the investigation the major experiments were made upon contact filters. Of these there were two primary beds, each 192 sq. m. (.048-acre) in area, and 80 cm. (2.6 ft.) deep, and two secondary beds each 224 sq. m. (.055-acre) and 70 cm. (2.3 ft.) deep. The shallow beds were made necessary by the low available head. The beds were all filled with crushed slag of three grades, the bottom third being filled with material ranging from 5 to 10 cm. (2 to 4 ins.), the middle third, 2 to 5 cm. (0.8 to 2 ins.) and the top third, 0.5 to 2 cm. (0.2 to 0.8 ins.). The open space was found to be 33% of the volume, giving a capacity of about 67 cu. m. (17,200 gals.) per bed.

After 15 months of continuous service one set of contact beds, primary and secondary, was replaced by a single trickling filter 400 sq. m. (0.1-acre) in area and 1.58 m. (5.2 ft.) in depth. One-half the bed was underdrained with inverted half tile, the remainder not being underdrained. Large pieces of crushed slag were placed over the bottom and the remainder of the bed was filled with crushed slag as it came from the crusher, with the fine dust screened out. It was presumably similar to that used in the contact beds, i. e., 5 mm. to 10 cm. (0.2 to 4 ins.). The surface was ridged in parallel ridges and had a slope of 0.3%. The ridges were 0.5 m. (19 ins.) apart and each hollow corresponded to an outlet in the dosing trough running along the side. There were six independent sets of these troughs, each dosing nine of the surface furrows, and fed by six automatic siphons discharging once every ten minutes and requiring 50 seconds for complete discharge. These are the maximum rates. During the night the rate was allowed to fall off. It will thus be seen that the method of dosing was similar to that used in this country on sand filters.

The effluent left the bed through drains at the base of the lower retaining wall and was discharged without further treatment.

RATES OF OPERATION.—The rates of operation were allowed to fluctuate considerably, evidently being determined by the amount of sewage available. Through the septic tanks a maximum rate of 800 cu. m. was allowed, corresponding to 1.6 the tank capacity, but during the night the rate was allowed to fall. The average rates per day varied from 360 cu. m. to 650 cu. m., or from 0.72 to 1.30 the tank capacity. A similar variation was allowed on the filters. The daily mean rate on the trickling filter ranged from 500,000 to 1,000,000 gals. per acre per day. On the contact beds two and three fillings per day were given during the first year and one during the second, corresponding to net rates on the double system of 180,000 to 540,000 gals. per acre per day.

RESULTS.—The sewage before treatment was of the following average composition as regards parts per million of total solids: Dissolved, 460 organic and 750 mineral; suspended, 560 organic and 670 mineral.

The removal of suspended matter by the tanks was exceptionally good, being 95% of the organic matter and 96% of the mineral matter. This represents the combined effect of the detritus and septic tanks. About 1.5% of the suspended matter was removed in the former. There was but little deposit in the tanks, averaging 15 cm. (3 ins.). This sludge was 66% mineral matter. A heavy scum was formed at the inlet and decreased to almost none at the outlet. No appreciable advantage was found in the covered tank over the open one.

The work of the filters is well shown in the accompanying table of analyses. Nitrification seems to have been very poor in the contact beds, when the fineness of the material is considered. Otherwise the results are normal as compared with those obtained elsewhere. The advantage of the trickling filter over the double contact system is striking. The final effluent without any sedimentation surpasses that of the contact beds, while the rate was for the most part about five times as high. One cannot but surmise that the excellent showing made by the trickling filter with the crude method of distribution in use was largely due to the fineness of the material. Not much information is given as to clogging, but it is stated that the surface had to be raked over occasionally to keep it porous. It is apparent that the furrows of the surface are entirely submerged at each flooding and that we have here a sort of well underdrained intermittent filter and not a trickling filter as known elsewhere. The results are therefore all the more interesting as illustrating a rather new type of filter, and it is to be hoped that further data on its permanence will be forthcoming.

CHEMICAL ANALYSES SHOWING RESULTS OF MADELEINE EXPERIMENTS ON SEWAGE TREATMENT.

(Parts per 1,000,000.)

Average Results for the Year 1904-1905.

	Nitrogen as—				Oxygen consumed (cold)		
	Free ammonia.	Organic.	Nitrates.	Organic carbon.	3 min.	3 min. after incubation.	4 hours.
Septic tank ..	9.1	11.9	0.2	145	11	18.1	22.4
Primary contact.	4.7	8.7	1.3	77	5.2	5.7	12.6
Secondary contact.	2.6	6.5	4.0	50	3.6	3.0	9.2
Average Results of Four Analyses, January to May, 1906.							
Raw sewage ..	7.8	11.8	..	155	..	..	21.6
Septic tank ..	9.5	7.9	..	67	..	..	22.7
Primary contact.	8.4	4.7	1.5	24	5.2	6.6	13.3
Secondary contact.	3.3	3.0	4.0	15	3.8	3.2	9.6
Trickling filter ..	2.9	2.1	5.9	11	2.8	3.0	7.4

CENTER-BOUND TRACK AS A CAUSE OF SPREADING RAILS.

In the maintenance of railway track the disadvantages of tamping ballast hard under the middle of the ties, so as to cause a center-bound track, are generally recognized. From various causes, however, this condition does occur at times, and is liable to result in the rocking of track (with possibly a dangerous effect upon the trains), and in a distortion of the proper alinement. In some cases ties may even be broken due to their being more solidly supported at the center than at the ends. In a recent communication, Mr. Emmet Keough, of the Illinois Central R. R. (at Champaign, Ill.), suggests this action as a possible cause of the disastrous derailment accidents on the New York Central Ry. at Woodlawn, N. Y., and the Pennsylvania R. R. at Mineral Point, Pa. He considers that center-bound track is one of the common causes of spreading rails. This opinion he bases upon 12 years experience in the actual work of track maintenance on railways of the middle-western states, and he has discussed the subject in a paper which we print below.*

*Abstract of a paper in "The Technograph," University of Illinois, Champaign, Ill.; Vol. xxi., 1906-07.

By the use of tie-plates and rail-braces as well as through the general improvement of track structure, many reputable engineers claim that the spreading of rails has been practically eliminated, and that recent accidents, caused by the spreading of rails, were in no way due to defective track.

It is the intention of the writer, however, to show how such accidents may happen even on a first-class rock ballasted road. When a train passes around a curve, the wheels have a tendency to continue in a straight path. Through the front outer wheel of the truck, a lateral force acts on the rail, causing an outward movement of the same. According to Wellington this lateral thrust is equal in magnitude to 75% of the gravity force acting vertically. Under perfect conditions the resultant of these two forces will act at an angle of about 65° to the horizontal. In order to secure and retain this ideal condition, experience has shown that the tie must be so adzed that the rail when first laid, will incline slightly inward. Traffic soon brings the tie and rail into the desired relation and, in so doing, affords a better bearing for the rail. With rails so placed, the friction between the rail and the tie, and the holding power of the rail fastenings, overcome the lateral thrust and keep the rail in place.

When fine ballast is used, the center of the track is sometimes ridged above the top of the tie with the intention of holding the track in better alinement. This practice is good for its purpose, but it has an accompanying fault. Small particles of the ballast work under the inner flange of the rail and cause an outward inclination of the same. This naturally widens the gage and renders conditions favorable for rail spreading.

Spreading rails seldom give trouble except during frozen weather. When the ballast is not frozen, the rail fastenings and the friction between the rail and the tie force the ties to move outward with the rails at places where the roadbed is weak. When the ballast is frozen, however, the ties are held firmly in place through the action of the frost, while the force due to the lurching of the cars causes the rails to move independently of the ties. During freezing weather any small amount of moisture under the base of the rail becomes frost. This reduces the friction between the rail and the tie, and thus allows most of the lateral thrust to act directly on the outer rail fastenings. With this reduction of friction, a force under normal conditions not at all dangerous, may easily produce a lateral movement of the rails. The spreading of rails is not confined alone to curves, but happens frequently on straight track. This is often due to low rails which cause the cars to lurch toward the lower side, but center-binding is the main cause for all kinds of spreading.

On first-class roads accidents due to spreading of rails, caused by either improperly laid rails or bad surface, are few. The worst examples of spreading rails occur on fills or on curves which encircle hills. Such cases are most often caused by center-bound track; or track which has a more firm bearing under the centers than under the ends of the ties. Track becomes center-bound on fills because the earth is more compact in the fill under the center than under the ends of the ties. This allows the greatest settlement where the most weight occurs. On double-track, the outside rails are over the weakest part of the fill and are invariably the ones which are displaced when spreading occurs. Since the ballast contains more moisture under the center of the track than in the shoulder at the ends of the ties, there will be more heaving by the frost under the center than at the ends of the ties; and afterwards, the track will become more center-bound than before freezing. As thawing occurs last under the centers of the ties, the resulting ridge of frozen ballast will cause a much greater bearing at the center of the ties than under the rails, and consequently produce a worse form of center-binding. The force of gravity acts through the wheels on these rails in exactly the same manner as in the case of tilting rails on curves or of low rails due to irregular surface. Not only does the center-binding increase, but through the inclination of the ties due to center-binding, friction between the rail and the tie becomes less, and hence the spreading of the track is rendered much more probable.

One of the best roads in the middle west, during the winter of 1905-06 had an unusual amount of trouble with spreading rails due to this cause. Several places were found where the rail had spread over 1½ ins. in a single night. This track appeared to be in first-class condition, and was a portion of the best division on the system, but it had not been surfaced out of a face for several years. This track was then given a light, general raise, and the ties were tamped only 8 or 10 ins. inside each rail. Not a single case of spreading occurred during the following winter of 1906-07.

While many trackmen have not recognized the fact that center-binding produces spreading rails, yet some, aware of the cause and the danger, use various means to prevent it. One method used by a few trackmen is to tamp only the ends of the ties the day the track is raised and to finish the center tamping a day or two later. This method has many disadvantages, but the one which concerns center-binding is that the tampers often raise the track slightly by tamping the centers too hard

and thus cause what was intended to be avoided, center-bound track. In coarse ballast the track should be tamped only 10 or 12 ins. inside of each rail; and in ballast which does not drain readily, the centers should be shovel tamped lightly so as to leave no large pockets for water. A good example of a perfect bearing track is that of a well-designed bridge which has the stringers placed outside the rails. Even though soft ties are frequently used without tie plates or braces on such track, spreading never occurs.

In order to secure perfect bearing on fills, embankments and ballast shoulders should be much wider, and ballast should be dressed level to the full length of the tie to avoid unequal heaving of the ballast under the tie. The ordinary 8-ft. tie is thought by many trackmen to be the cause of center-binding on account of the inequality of the bearing surfaces outside and between the rails. On account of the extra amount of material required for making longer ties there will probably be no change until a steel or concrete tie takes the place of the wooden one. A reinforced concrete tie which is now being tried on the Chicago & Alton Ry. is made in such a manner as to have no bearing in the center. This construction not only prevents center-bound track, but requires less material than longer ties and will doubtless prevent track from becoming center-bound.

CLEANING AN 8-IN. CAST-IRON WATER MAIN IN PITTSBURG, PA.

By J. D. UNDERWOOD.*

Owing to the considerable friction loss in carrying capacity and pressure head caused by the tuberculation of its interior surface, a section of 8-in. cast-iron water main, 3,264 ft. long, has recently been cleaned in the city of Pittsburg, Pa., with remarkable results.

This pipe line has been in service for 14 years, and for the last five or six years the pressure in the territory supplied through it has been gradually growing lower, until just before it was cleaned the pressure at the end of the pipe was 34 lbs. below the theoretical static head.

It was proven by pitometer measurements that there was no leak in the pipe, and piezometer readings at several points along its length showed that the drop in pressure was nearly uniform throughout, amounting to 2.406 ft. of head per 100 ft. of length. This is equivalent to a velocity of about 6.8 ft. per sec. in new pipe, while the velocity then existing in the pipe was but 2.43 ft. per sec.

In making the pitometer test above referred to, it was discovered that there was a coating of scale on the interior of the pipe which reduced its effective diameter to about 7½ ins. As the loss in pressure head could be accounted for in no other way, it was decided to clean the pipe. The contract for the work was let to the National Water Main Cleaning Co., of New York City.

Owing to the fact that the pipe was the main supply line for a considerable district, it was impossible to keep it shut down continuously, and this delayed the work so that about a week was consumed, when ordinarily three or four days should have sufficed to clean this length of pipe. A foreman, a mechanic and seven laborers were employed during the entire time.

The process consisted of cutting the main at the head and inserting a special Y connection into which the cleaner could be introduced. Then at a distance of from 400 to 1,200 ft., according to local conditions, another cut was made, and a similar special inserted, from which a waste pipe and flume was led to a near by sewer drop, to carry off the discharge. These special Y fittings are so made that a cover can be readily bolted to them, should any emergency requiring that the main be replaced in service arise.

After the fittings are in place, a "Go-Devil" (Fig. 1), carrying a No. 22 flexible wire cable, is inserted in the up-stream fitting, and the water turned on behind it, forcing it through the pipe. The water is then shut off, the "Go-Devil" disconnected, and a ⅝-in. wire cable connected in its place and drawn back through the pipe by means of a small one-man winch. Here the "Cleaner" (Fig. 2) is attached and placed in the pipe, the cover of the special Y bolted on and the water turned on again, while the "Cleaner" is dragged through by a four-man winch, the water washing the broken scale out of the pipe ahead of it. This completes the cleaning operation, which must be repeated for each section so cleaned.

*Assistant Engineer, Bureau of Water, City Hall, Pittsburg, Pa.

The following data of the above process were obtained while cleaning a section 790 ft. long, and these figures, barring accidents, held fairly constant during the entire work:

From time water was turned on until "Go-Devil" came through	3 minutes
Time required to pull ⅝-in. cable back through pipe	38 "
Time required to pull "Cleaner" through pipe	48 "

A box was placed to catch the scale washed out of the discharge end, and a 6-in. Crest meter was set at the beginning of the line to test the flow through the pipe while discharging freely into the air, five-minute readings being taken before and after cleaning.

The results of the meter and pressure gage tests, and of the general operation, follow:

	Before cleaning.	After cleaning.
Diameter, ins.	7½	8
Loss of head per 100 ft., in feet	2.406	0.495
Mean velocity, with 77 lbs. pressure at head, ft. per sec.	5.3	10 3
Discharge in five minutes, gals.	3,650	8,100
Increase of discharge, per cent.		121
"c" in formula $v = c\sqrt{R\,S}$	86 9	164.1
"n" in Kutter's formula	0.0182	0.0103
Pressure* on Hydrant No. 19, lbs.	53	60
Pressure on Hydrant No. 7, lbs.	67	93
Pressure on Hydrant No. 8, lbs.	77	104

*With line in regular service.

The scale taken from the lower section of the line, about 710 ft. long, amounted to 1½ cu. yds., which is equivalent to 98.5 cu. ins. per lin. ft., or to a coating averaging 0.32-in. thick. This coating was very rough and uneven, varying from ⅛ to ⅜-in. in thickness. Two masses of lead, caused by defective "yarning" when the joints were poured, were removed from the pipe. One of these, which caused the cleaner to stick in the pipe, weighed 45 lbs.

The cost of cleaning the pipe was 24 cts. per ft., all labor and material being furnished by the contractor, and the surface of the streets and park land, through which the pipe line ran, being replaced by him to the satisfaction of the superintendent of the bureau of water. One man was furnished by the city to make the necessary shut-offs, and to notify consumers of the duration of water shortage.

Fig. 1. Inserting the Go-Devil.

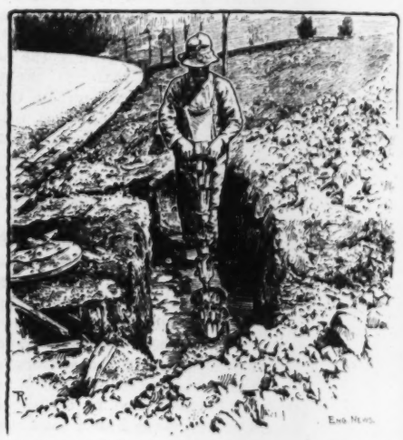


Fig. 2. Inserting the Cleaner.

FIGS. 1 AND 2. CLEANING AN 8-IN. CAST-IRON WATER MAIN AT PITTSBURG, PA.

A SUBTERRANEAN CANAL 4.3 miles in length, says a dispatch from Paris, is projected to connect the valley of the Rhone with the port of Marseilles. This tunnel will be, in point of quantity of material excavated, the largest in the world—2,840,000 cu. yds, estimated, against about 1,375,000 cu. yds, for the Simplon tunnel. The latter is 13.8 miles long, but only 24 ft. wide and 18 ft. high; while the canal tunnel would be, with the towpaths on either side, 66 ft. wide and 42 ft. high. The canal would permit two barges to pass at any point. The cost of the tunnel, rendered necessary because the hills between the Rhone and Marseilles are too high for lock operation, is estimated at $6,900,000; the total cost of the canal $15,200,000.

STANDARD TURNTABLE PIT: SEABOARD AIR LINE RY.

By PHILIP AYLETT,* Assoc. M. Am. Soc. C. E.

During the writer's service as bridge engineer of the Seaboard Air Line Ry., the large increase in mileage and traffic demanded heavier power, which necessitated not only improvements in bridges, but also longer and heavier turntables. The old 60-ft. turntables (of various manufacture) at main division points were taken out, repaired and strengthened and placed at points of minor importance, or consigned to the scrap pile when found unworthy of repairs.

The new tables were all 70 ft. in length and designed for Coopers E 50-loading.

All of the old turntable pits were constructed with brick circular walls 60 ft. in diameter. Some of the old pits were paved originally with brick and all of them had wood cross-ties under the circular track. In several cases the spaces between the cross-ties had been filled with concrete—a bad practice.

It was found in repairing some of these old tables that the damage to them was due to settlement of the circular track, thus causing excessive impacts from engines passing on and off the tables.

Turntable pits generally are badly drained, either on account of lack of fall in the pipe or on account of pipes being blocked up by dirt, coal, old waste, rags, etc., for which trainmen always make the turntable pit a dumping ground.

On account of bad drainage and high concentrations on trailing wheels, excessive settlement of the wooden ties in the damp ground is found in almost every case, resulting in injury to pivots and other portions of the table.

In order to overcome this evil (which the writer found to be the source of the majority of turntable expenses) a pit was designed as shown in the drawings, consisting essentially of a concrete circular wall, in the foundation offset of which is embedded and bolted the circular rail as shown.

In constructing the concrete wall, when the elevation of the base of the circular rail is reached, tie-plates located about 5 ft. apart are set radially to exact elevation of rail base and upon these plates the circular rail is placed and bolted in position by the special staybolts previously embedded in the concrete foundation. The concrete is then carried to the top of the rail, at which elevation the neat line of the circular wall begins. It will be noted that a fall of 1 in. between the bottom of the wall and the circular rail is provided for drainage.

The pits are paved with 1:2½:5 concrete, 4 ins. in thickness. This paving was generally deposited on the old brick pavement, after that had been thoroughly cleaned. Two bricks in every 3 sq. ft. of surface were removed from the old pavement in order to give perfect bond to the concrete pavement.

Concrete pavement is divided into radial blocks, the joints between the blocks providing

*Terminal Engineer, Virginia Ry., Norfolk, Va.

for expansion. The pavement is given a regular sidewalk finish.

In all cases, that portion of the drainage pipe coming within the pit and under the wall is of iron 8 ins. to 10 ins. diameter, according to the fall. The drainage pipe leads from a concrete

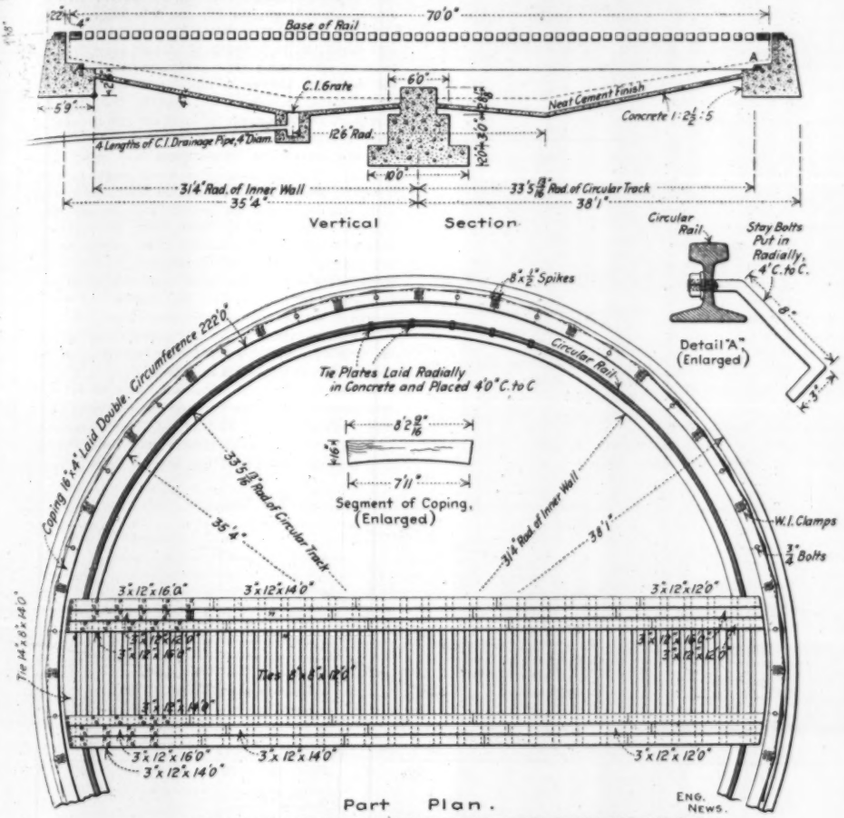


FIG. 1. STANDARD 70-FT. TURNTABLE PIT; SEABOARD AIR LINE RY.
Designed by Philip Aylett, Assoc. M. Am. Soc. C. E.

catch-basin covered over by a cast-iron grating. The catch-basin is located at the lowest point in the pit area.

The coping of the circular wall is composed of 16 × 4-in oak or pine laid double. The segments being about 8 ft. long and the two layers breaking joints as shown. Coping segments are cut to the calculated dimensions as given at the division shops and shipped to the site. The coping is securely bolted to the wall by ¾-in. × 3-ft.

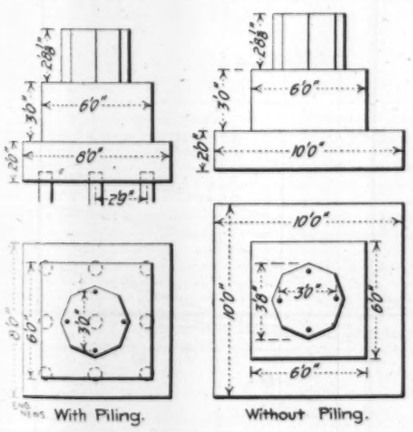


Fig. 2. Details of Center-Bearing for Standard 70-Ft. Turntable.

bolts embedded vertically in the concrete, their tops or threaded ends projecting above the walls the exact thickness of the double thickness of coping (8 ins.).

Holes are bored in coping segments to receive the embedded bolts, which pass between the butt joints in the bottom layer and consequently through the center of top segments. Nuts and washers are countersunk. To give further strength, and especially to provide against warping of the wooden coping, four 8 × ½-in. spikes are driven near the joints of each segment at the locations shown, and a wrought-iron clasp 12 ins. long ties adjacent segments together.

A number of pits 60 ft. in diameter were replaced by the standard 70-ft. pit described. This was done without the least interruption of traffic on the old table.

Although some of the new pits have been built several years, the writer has never known settlement to occur in any case, nor has any irregularity occurred in pivots or other parts of new or old tables which have been installed in pits of this design, although in several cases the tables are operated by power, thus subjecting the rails to greater concentrations. A bill of material for the standard 70-ft. pit follows:

Bill of Material

No. Pcs.	Size, ins.	Length, ft.	Grade.	ft. B. M.	Remarks.
58	8 × 8	12	Yellow pine or W. oak.	3,712	Ties
2	8 × 14	14	" " " " "	261	Ties
4	3 × 12	16	" " " " "	192	Sidewalk
4	3 × 12	12	" " " " "	142	Sidewalk
22	3 × 12	14	" " " " "	924	Sidewalk
28	4 × 16	18	" " " " "	2,688	Curbing
			Total.....	7,919	

54 staybolts and washers for same.
50 lbs. 60d. wire nails.
28 wrought-iron clamps.
28 bolts, 36 ins. under head, ¾-in. diam.
28 washers for ¾-in. bolts.
28 3 × ⅜ × 12-in. anchor plates with ⅞-in. hole.
120 spikes, 8 × ½-in.
1 cast-iron grate.

	Cement.	Stone.	Sand.
220 cu. yds. concrete....	262 bbls.	210 cu. yds.	102 cu. yds.

THE SCHAFFHAUSEN FALL OF THE RHINE was protected from further "development" by the local Council, recently, when an application for permits for an extension was made by the electric company that now has a power plant at the fall. The Council passed a resolution denying the application and expressing the opinion that not only further exploitation should be prevented but also the present development should be discontinued at the expiring of the present franchise in 1928.

STANDARD GAGES FOR NARROW-GAGE RAILways in Hungary have recently been promulgated by the Ministry of Commerce. Future narrow-gage lines must employ one of two gages: 27½ ins. or 30 ins. (70 or 76 cm.). There is at present a large mileage of narrow-gage line in Hungary, covering a diversity of gages.

BREAKING PIECE FOR A SWINGING-JAW ROCK CRUSHER.*

By GILMOUR E. BROWN,† Stud. Inst. M. M.

In ordinary types of swinging-jaw rock crushers, that part designed to give way under an excessive stress is not close up to the point where the stress originates, but the pressure has to be transmitted through several members before reaching that possessing least strength.

The result is that the momentum of the flywheels, etc., is sufficient to cause severe strains in expensive parts of the breaker; and instead of the breaking pin on the driving shaft giving way, or the pitman cap flying off, one gets occasionally a bent pitman shaft or broken tension bolts.

The form of breaking piece here described was, the writer believes, first adopted in a breaker designed by Mr. Bigelow, of Messrs. Bewick, Moreing & Co.'s staff in Australia, but is now common throughout the mines in Western Australia.

The breaking piece consists of a toggle cast in halves, the halves being machined to fit together along a plane, making an angle of 20° with the direction of simple compressive stress. The halves are held together by six 1¼-in. rivets, in two rows 3½ ins. apart, the pitch of the rivets being 4⅛ ins.

These sizes are suitable for a toggle 19 ins. long by 15 ins. broad, and 3⅜ ins. thick at the center.

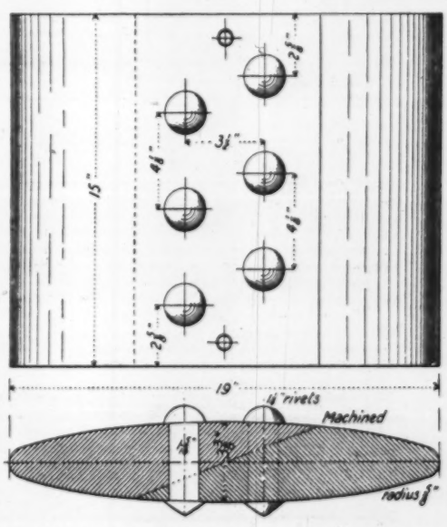
Planing up the halves and boring the holes for the rivets takes a machinist, on an average, eight hours.

The proportions given were adopted, after several trials, for a 15-in. by 9-in. Blake rock crusher, crushing moderately compact quartz through a throat opening having a maximum width of 2 ins.

The toggle is put in between the swinging jaw and the pitman, the other toggle being of the ordinary solid type.

This toggle never shears on ore, but when the jaws close on a hard object, such as a hammer head, the one half of the toggle slides over the other, quickly and cleanly and without damage to the castings.

The half toggles can then be riveted together again, and may be used thus several times before being finally discarded through wear. Taking the shearing resistance



Breaking Piece for Swinging Jaw Rock Crusher.

of the rivets at 43,000 lbs. to the sq. in., this toggle will shear under a direct and uniformly-distributed compressive stress of 141 long tons.

This form of breaking piece, though perhaps more expensive than the more common types, has, in this case, proved cheaper in the long run, and it has the advantage in a rush for tonnage that it allows the jaw to fall back when it shears, so that the breaker clears itself of ore and is ready for the insertion of another toggle.

STANDARD SIZES FOR TIES were discussed at the annual meeting of the American Railway Engineering and Maintenance of Way Association, and a letter ballot is now being taken as to the desirability of the adoption of specific sizes. The only argument advanced in favor of the adoption of standard sizes is facility in the making and purchasing of ties. The arguments against their adoption are that the desirable sizes of ties for any particular road are determined largely by the cost of ties and ability to procure them rather than by theoretical considerations; also, by the conditions of roads as to traffic, ballast, and character of roadbed. The association has heretofore indicated that no one standard size for all roads would be satisfactory.

*From Bulletin No. 28 of the Institution of Mining and Metallurgy, London, Jan. 10, 1907.

†Applegarth, Balloch, Dumbartonshire, Scotland.

INVESTIGATION OF THE THERMAL CONDUCTIVITY OF CONCRETE AND EMBEDDED STEEL AND THE EFFECT OF HEAT UPON THEIR STRENGTH AND ELASTIC PROPERTIES.*

By IRA H. WOOLSON,† E. M., M. Am. Soc. M. E.

This paper is a record of experiments made in continuation of an investigation begun two years ago, and partially reported‡ at the two previous meetings of the American Society for Testing Materials.

CONDUCTIVITY TESTS.

It was found last year that thermo-couples imbedded in blocks of concrete for purpose of measuring internal temperatures when the blocks were heated were likely to be shifted in tamping the wet mixture, thus making it difficult to measure the temperatures from exact positions. To obviate this trouble a single specimen was made with a series of holes running in from the back face to points at definite distances from the front face, to which heat was applied. The results obtained from this plan were so satisfactory that it was decided this year to repeat the experiment, using trap, gravel and cinder mixtures for comparison.

Two specimens of each mixture were made. Fig. 1 gives the size of the blocks, and the location of the holes in which the thermo-couples were placed. The arrangement was varied slightly from last year, in order to keep the outside couples from being affected by heat transmitted through the ends of the blocks from the furnace walls. Seven couples were used, and were so located as to indicate the temperature at points varying from ½-in. to 6 ins. from the heated face. It was found that this arrangement of couples nearly eliminated the effect of heat from the side walls. The method of test was essentially the same as that described last year, except that the duration of the test was cut from five hours to two hours. It was decided that the shorter period would give sufficient evidence to classify the different mixtures, while effecting a considerable saving in time. The aggregate used was a 1:2:4 mixture of cement, sharp sand, and ¾-in. crushed trap rock, or a corresponding size of clean quartz gravel. In the cinder mixture the proportion was changed to 1:2:5, and the cinder employed was a fair quality boiler cinder, with most of the fine ashes removed. The cement was an equal mixture of Atlas, Lehigh and Vulcanite. The concrete was mixed moderately wet and was well tamped. The specimens were left in the molds 24 hours, then placed in water for 48 hours; after this they were kept moist for two to three weeks, after which they were given a good opportunity to dry. They were about two months old when tested.

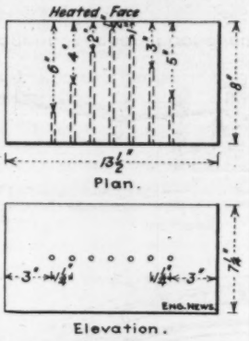


Fig. 1. Concrete Specimen with Cored Holes for Thermo-Couples for Measuring Heat Transmission.

The shape of the curve is much the same as [illegible] last year. There is the characteristic lag at [illegible] point, due to the evaporation of water in the [illegible]. The time required to do this increases with [illegible] distance inward from the heated face.

In Fig. 2 it will be noted that the curves f[illegible] of the points nearest the heated surface have a [illegible] depression between the 200 and 300° limits. This [illegible] probably due to the fact that the outer surface of th[illegible] was dried out to a depth of one or more inches [illegible] heat in this region rose gradually until it penetr[illegible] the moisture further in the block, causing it to [illegible] and forcing it outwards towards the heated [illegible], where it was turned into steam, thus absorbi[illegible] heat, and lowering the temperature. When the m[illegible] was evaporated, the temperature rose again in the [illegible] lar way. This peculiarity is not noticeable in the [illegible] concrete, probably for the reason that the concrete, [illegible] more porous, dried out better, and for the same [illegible] permitted the heat to drive what moisture ther[illegible] before it through the block. The curves of Fig. [illegible] permissible of very close comparison, since the [illegible] mens were all of the same age (2½ months), a[illegible] in the same condition. The curves of furnace [illegible] perature are also practically the same.

It will be noted that the conductivity characteristics for trap and gravel are almost identical, and that cinder is a better conductor than either.

In Fig. 3 the curves are not quite so satisfactory for two reasons: (1) The furnace temperatures were not as well regulated, due to various causes beyond control, and (2) two of the specimens had been subjected to a hot, drying atmosphere for several days in an effort to get rid of the interior moisture. However, the results are of value as confirmatory evidence.

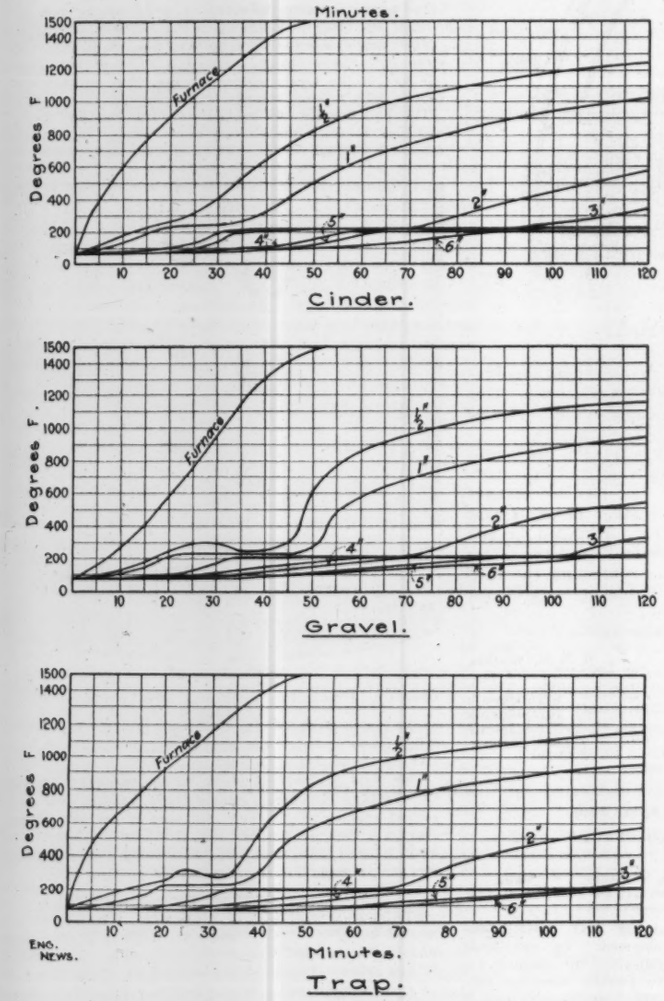


Fig 2.

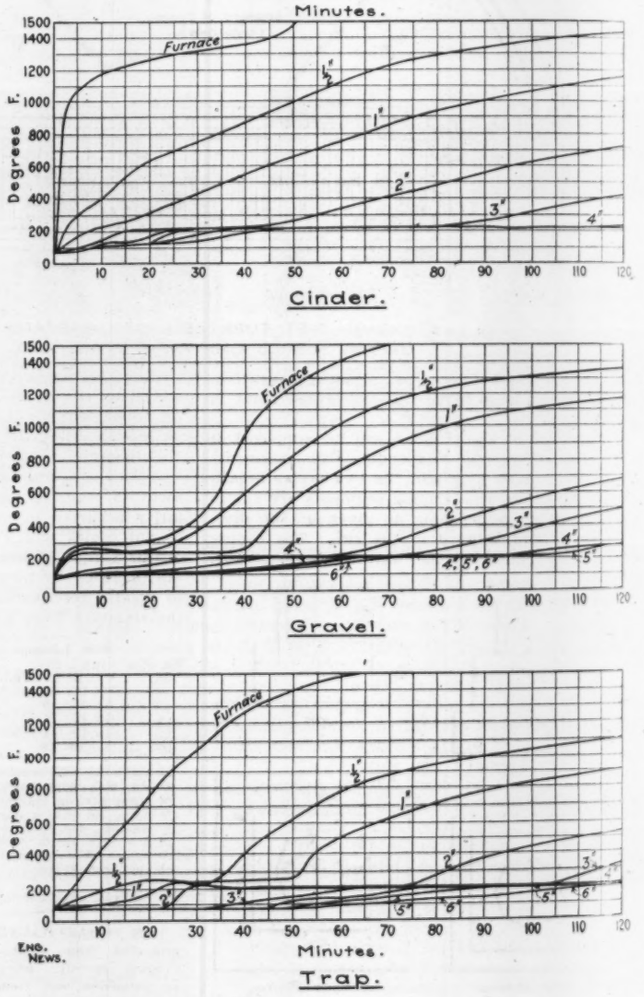


Fig. 3.

FIGS. 2-3. TEMPERATURE RISE AT DIFFERENT POINTS IN TRAP, CINDER AND GRAVEL CONCRETES.
(1 : 2 : 4 mixture for trap and gravel; 1 : 2 : 5 mixture for cinder.)
(Figures over each curve indicate distance from heated surface readings were taken.)

In making the tests the furnace temperature was brought up to 1,500° F. in approximately 45 minutes and held there throughout the remainder of the test.

Figs. 2 and 3 are the curve sheets for these tests. Each curve is marked with a figure indicating the distance from the heated surface at which the readings were taken. There are duplicate tests of each mixture.

The conclusions we may draw from this data are:

All concretes have a very low thermal-conductivity, and herein lies their ability to resist fire.

When the surface of a mass of concrete is exposed for hours to a high heat, the temperature of the concrete

*A paper read before the American Society for Testing Materials at Atlantic City, N. J., June 21, 1907.

†Adjunct Professor of Mechanical Engineering, Columbia University, New York City.

‡Eng. News, July 13, 1905, pp. 35-38; June 28, 1906, pp. 723-725.

one inch or less beneath the surface will be several hundred degrees below the outside.

A point 2 ins. beneath the surface would stand an outside temperature of 1,500° F. for two hours, with a rise of only 500° to 700°, and points with 3 or more inches of protection would scarcely be heated above the boiling point of water.

The fact that the cinder concrete showed a higher thermal-conductivity than the stone concrete would indicate that its well-known fire-resistive qualities are due, in part at least, to the incombustible quality of the cinder itself.

Although the thermal-conductivity of the gravel concrete was fully as low as that of the trap, it must nevertheless be condemned as a first-class fire-resisting mixture. All the specimens of gravel concrete tested were badly disintegrated by the heat. The gravel specimens would crack and crumble in pieces when the trap and cinder specimens under similar treatment would remain firm and compact.

These results are in complete confirmation of those reported last year, which were received by some of the membership with considerable skepticism.

The writer is convinced that concrete made from this particular gravel is not reliable as a fire-resisting material. Whether other grades of gravel would give equally unsatisfactory results is a matter for investigation.

The cause for this failure of the quartz mixture is not easy to locate. The most plausible reason seems to be the relatively large coefficient of expansion of the quartz. It is about twice that of feldspar, which is one of the predominant minerals in trap rock. Clark's "Constants of Nature," published by the Smithsonian Institute, gives the cubical coefficient of expansion for these minerals as follows:

Quartz	0.000036
Feldspar	0.000017

According to the same authority, quartz has another peculiarity of expansion; the expansion in the direction of the major axis is only half that in the direction of the axis perpendicular thereto. This unequal expansion may further contribute to its tendency to disintegrate the concrete under action of heat.

Since the distribution of gravel is much more general than trap, the subject is of much importance, and tests should be made to determine if other gravels are equally defective.

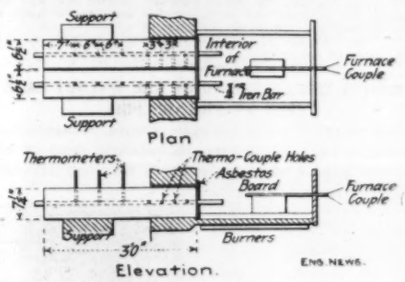


Fig. 4. Specimen for Testing Conductivity of Embedded Steel Rods.

CONDUCTIVITY OF EMBEDDED STEEL.—In connection with the investigation of the conductivity of concrete itself, some tests were made to determine the conductivity of steel embedded in concrete. In making fire tests upon full size reinforced concrete floors the writer has noticed that a reinforcing rod exposed for hours to a bright red heat would develop a temperature of only a few hundred degrees in adjacent portions embedded 2 or 3 ft. in the concrete. This fact suggested the idea of this part of the investigation.

The specimens for this test were made by embedding ¾-in. square steel bars in blocks of concrete 3 ft. long and 8 ins. square. The bars projected 6 ins. beyond the end of the concrete. Holes ¼-in. deep were drilled into the bars at regular distances apart, and corresponding holes made in the concrete. (See Fig. 4.) Two specimens of each mixture were made under the same conditions as the other specimens, and were tested when about two months old.

Two specimens at a time were placed with the projecting bars in the doorway of the furnace, the concrete being of such size that it completely filled the openings.

Thermo-couples were inserted in the holes in the bars nearest the fire, and thermometers in the others. The temperature of the furnace was raised to 1,700° F. in an hour and held there for an hour longer. Temperatures were read in each hole every five minutes. The idea of the test was that the projecting ends of the bars would be held at a high heat while the concrete would be comparatively cool, except the end which faced the fire.

The results are shown in the curves in Figs. 5 and 6. Each curve is numbered to indicate the distance of the point at which readings were taken for that curve, from the heated face of the concrete.

As iron is known to be a good conductor of heat it was expected that a considerable portion of the embedded bar would attain a temperature nearly that of the exposed end. It was therefore surprising to find that after the projecting end of the bar, and the end face of the concrete, had been held at a temperature of 1,700° F. for an hour, a point in the bar only 2 ins. from the heated face of the concrete had developed a temperature of only 1,000°, or a drop of 700°. Fig. 5 shows this very

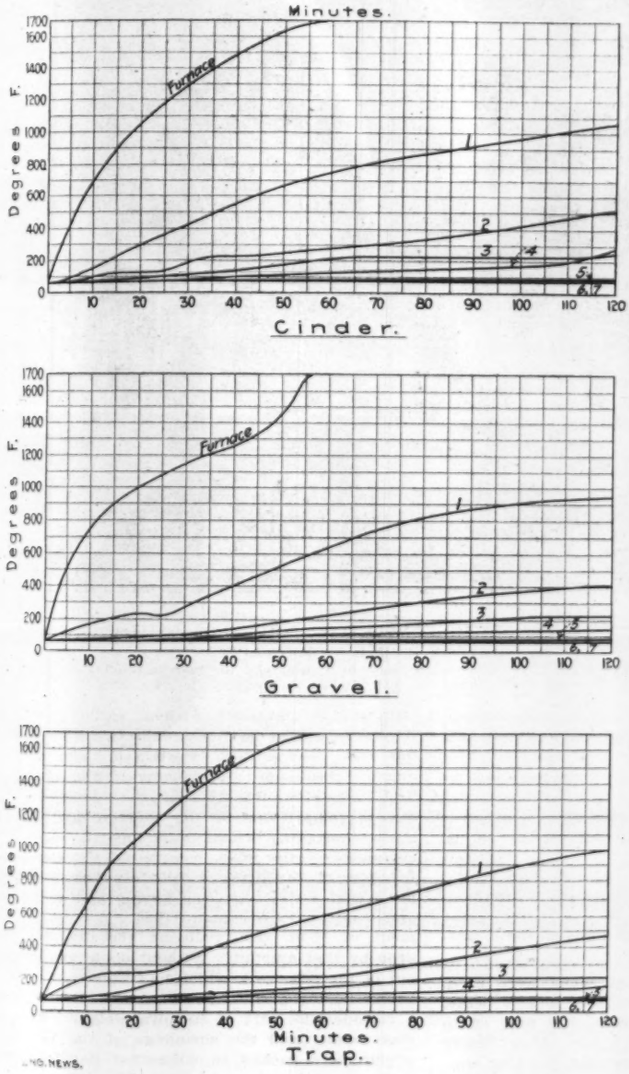


Fig. 5.

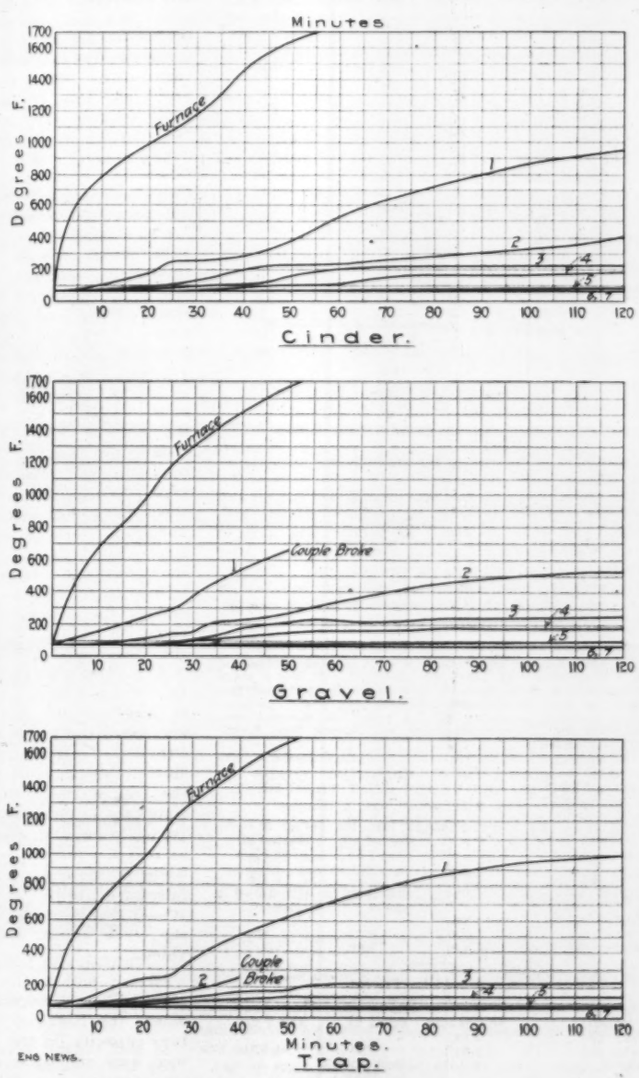


Fig. 6.

FIGS. 5-6. TEMPERATURE RISE AT DIFFERENT POINTS OF STEEL RODS EMBEDDED IN VARIOUS CONCRETE MIXTURES.

(Figures on each curve indicate the distance of the point at which readings were taken, as follows:

No. 1 = 2 ins.	No. 3 = 8 ins	No. 6 = 23 ins.
No. 2 = 5 ins.	No. 4 = 11 ins.	No. 7 = 29 ins.
	No. 5 = 17 ins.	

clearly. It also shows that a point 5 ins. in the concrete acquired a temperature of only 400° to 500°. Also that a point 8 ins. in, only reached the temperature of boiling water, and the balance of the bar retained very little heat. The results were practically the same for all three mixtures. The curves show the usual lag due to moisture, but this is less apparent in the cinder mixture, showing it was dryer.

Although these results are very interesting, it was discovered that they were somewhat misleading, for by testing one of the same bars without the concrete in the open air with one end heated over a gas furnace, it was found that the travel of heat along the bar was really very small. Only a single test was made, but it served to demonstrate the fact that air radiation protected the bar from heat as well as did the concrete. Fig. 7 shows the results of this test. The points are the same as in the previous tests. The test was continued for only one hour, for the parallelism of the curves indicated that the rate of radiation was just equaling the rate of reception.

These experiments indicate that where reinforcing metal is exposed in the progress of a fire, only so much of the metal as is actually bare to the fire is seriously affected by it.

STRENGTH TESTS.

A few tests were made to determine the strength and elasticity of the different mixtures both with and without heat treatment. The heat was raised to 1,500° F. in 45 min., and held there for the remainder of the test.

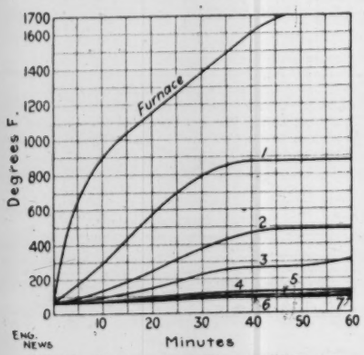


Fig. 7. Temperature Rise at Different Points of Steel Rod in Open Air.

(Same figures for distance from heated point as Figs. 5-6.)

The results of these tests are given in the accompanying tables.

The tables show the usual deterioration due to heat, also that the trap was decidedly the strongest mixture both before and after heating. The gravel was next in grade when unheated, but was a complete failure after heating even for one hour on one side only. The cinders gave the least strength of all—about half that of the trap, with corresponding weakening due to heating.

SUMMARY.

We may draw the following general conclusions:

(1) That all concrete mixtures when heated throughout to a temperature of 1,000° to 1,500° F. will lose a large proportion of their strength and elasticity, and this fact must be well remembered in designing.

(2) That all concretes have a very low thermal conductivity and therein lies their well-known heat resisting properties.

(3) That as a result of this low thermal conductivity, two to two and a half inches of concrete covering will protect reinforcing metal from injurious heat for the period of any ordinary conflagration (provided, of course, that the concrete stays in place during the fire).

(4) That reinforcing metal exposed to the fire will not convey by conductivity an injurious amount of heat to the embedded portion.

(5) That the gravel concrete was not a reliable or safe fire-resisting aggregate.

TABLE I.—COMPRESSION BREAKING LOADS OF CONCRETE BLOCKS UNDER HEAT TREATMENT.

7 × 7 × 7-in. Specimens. Age, 2 months.

Material.	Breaking load, lbs. per sq. in. Not heated.	Heated all over 1 hr.	Heated all over 2 hrs.
Trap (a)	2,460	1,690	1,011
Trap (b)	2,520	1,767	1,198
Gravel (a)	1,684	(Crumbled in pieces.)	(Crumbled in pieces.)
Gravel (b)	1,730	.....	.....
Cinder (a)	1,090	621	455
Cinder (b)	1,420	796	.....

6 × 6 × 14-in. Prisms.

Material.	Breaking load per sq. in. Not heated.	Heated one side 1 hr.	Heated one side 2 hrs.
Trap (a)	1,945	.....	.....
Trap (b)	1,845	1,280	1,120
Gravel (a)	1,370	(Broke while handling.)	.....
Gravel (b)	1,355	800	.....
Cinder (a)	978	800	.....
Cinder (b)	873	810	.....

TABLE II.*—MODULUS OF ELASTICITY IN 6 × 6 × 14-IN. PRISMS UNDER DIFFERENT LOADS.

Age, Two Months.

Material.	Loads. 200 lbs. per sq. in. Unheated.	200 lbs. Heated 1 hr.	200 lbs. Heated 2 hrs.	400 lbs. per sq. in. Unheated.	400 lbs. Heated 1 hr.	400 lbs. Heated 2 hrs.	800 lbs. per sq. in. Unheated.	800 lbs. Heated 1 hr.	800 lbs. Heated 2 hrs.
Trap	2,180,000	182,000	348,000	2,000,000	255,000	296,000	1,789,000	304,000	309,000
Gravel	828,000	98,000	.....	858,000	132,000	.....	960,000	171,000	.....
Cinder	858,000	255,000	.....	685,000	283,000	.....	505,000	218,000	.....

*See similar table, Engineering News, June 28, 1906, page 725.

MOVING THE CENTERING OF THE WALNUT LANE ARCH AT PHILADELPHIA.

The Walnut Lane Bridge across Wissahickon Creek in Philadelphia has in its main span of 232 ft. the largest masonry arch in this country and the largest concrete arch in the world. The design of the bridge was completely described in Engineering News for Jan. 31, 1907, together with the method of erection on a falsework centering, which was to be first erected under one of the parallel arch rings, and after that ring had been finished, moved over on rollers to its position under the other twin ring. The first arch ring was finished some months ago, and the moving of the immense timber and steel falsework was successfully accomplished during the past fortnight.

This centering consists of six stories of timbering resting on one bent of structural steel, which in turn rests on concrete piers founded in the creek bottom. The falsework is 147 ft. high, 232 ft. long and 50 ft. wide at the bottom. Its total weight is about 900 tons. On top of the concrete piers a plate of sheet steel is fastened, upon which are set cast steel rollers, bearing the weight of the centering. The method of moving the structure is shown in Fig. 2. When the concrete piers were laid 12 × 12-in. blocks were put in just outside the exterior bent and extending for about a foot beyond the concrete on either face. At the extreme end of the piers 12 × 12-in. stringers were laid across the piers and in the line of the bridge. The cross timbers and embedded blocks were then connected by a heavy 1½-in. diameter studded anchor chain, acting as reaction for the jacks, which worked between timbers extending from the bottom chord of the falsework bent to the longitudinal timbers. Where it was impracticable to use chains, as at the creek banks, special anchorages were provided.

Fifteen ball-bearing ratchet jacks were used, six of 35 tons capacity for the middle bents, where the heaviest loads come, and nine of 15 tons capacity on the outside bents. About thirty men were employed in the moving, working simultaneously at signals. The average movement was about one inch in two minutes. The whole distance of 34 ft. was covered in three w[illegible] days. Care was taken to preserve correct [illegible] ment by observation at each movement of [illegible] and at no time did this alinement vary by [illegible] than 1 in.

Close examination fails to discover the slig[illegible] indication of a crack anywhere throughou[illegible] great arch. The method of construction [illegible] mitted the deformation of the centering wit[illegible] causing any initial stress in the arch ring. [illegible] the result proves the method of design of [illegible] arch, and the accuracy of the application of [illegible] for the ring, through the character of its [illegible]

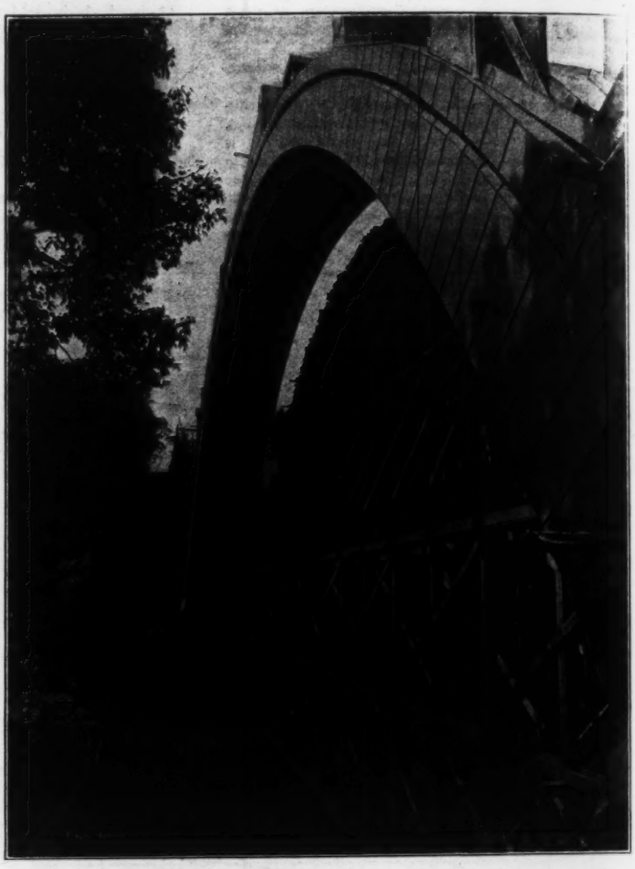


FIG. 1. ONE OF THE COMPLETED ARCH RINGS OF THE WALNUT LANE BRIDGE, PHILADELPHIA.

(Centering, 232 ft long, 147 ft. high, 50 ft. wide has just been moved, 34 ft. from under the completed arch for use in erecting the twin arch.)

struction, is absolutely without tensile value in its section. The maximum deflection upon striking was 1/16-in. at the crown and 1/32-in. at the quarter points, no other change being detected. The calculated deflection of the unloaded ring due to compression of the concrete and consequent shortening, exclusive of any allowance for shrinkage of the keys, was ⅜-in., but the temperature of the mass of concrete rose probably more than 10° F. between keying and swinging, and this expansion would cause a counter movement of ¼-in. rise, reducing the deflection or drop by that amount. Without doubt the drying out of the falsework which had been well wetted before keying gradually caused the arch to take a considerable part of its own weight before it was swung, and the shrinkage of the 17 keys, which were packed in somewhat like masonry underpinning, was simply not discernible.

Fig. 1 shows the entire falsework translated 34 ft. to its final position. The ease with which the operation was carried out is due to the painstaking care and preparation of Mr. Chambers Lattimer, Superintendent, Mr. Moriz Bernstein, Engineer, and Mr. T. H. Riddle, all of the firm of Reilly & Riddle, Contractors for the bridge. We are indebted for the photographs and description to Mr. Bernstein and to Mr. Henry H. Quimby, Engineer of Bridges of the City, in whose office the bridge was designed.

TESTS OF THE ADHESION OF STEEL TO CONCRETE IN BEAMS.

Some interesting experimental data on the adhesion of reinforcing steel to concrete in reinforced concrete beams have recently been reported to the Boston Society of Civil Engineers by Prof. L. J. Johnson, of Harvard University. The following account of the tests is taken from the Journal of the Association of Engineering Societies for June, 1907:

I wish to place on record some very high and perhaps unprecedented values for unit shears and unit adhesion stresses. They are results obtained in the actual working conditions of a beam, and computed, as seems clearly proper, by the same methods which one should use in designing a projected beam or girder.

The particular methods which I have in mind have been in use in Europe and, to some extent, in this country for several years past, but as I believe they are still somewhat unfamiliar, and as they are as simple as they are logical, I will venture here to state their deduction.

Let AB and CD, Fig. 1, be two right sections of a rectangular beam with single reinforcement, the distance between them, $\triangle x$, being so short that the vertical shear, V, at one section differs only immaterially from that at the other. Call the bending moment at the two sections M_1 and M_2, respectively. Then, as is well known, $M_2 - M_1 = V \triangle x$. If b be the breadth of the beam, the maximum unit shear may be written,

$$f_s = \frac{P_2 - P_1}{b \triangle x} = \frac{T_2 - T_1}{b \triangle x}$$

as will be realized upon observing that the total horizontal shearing tendency is the amount by which P_2 differs from P_1, which is the same as the difference between T_2 and T_1, and that the unit shear is the total horizontal shear divided by the area, $b \triangle x$, on which it is resisted.

But if h' be the distance between the centroids of tension and compression, that is, the arm common to the resisting couples composed of P_2 and T_2, and P_1 and T_1, respectively, then

$$P_1 = T_2 = \frac{M_1}{h'} \text{ and } P_2 = T_2 = \frac{M_2}{h'}, \text{ and}$$

$$P_2 - P_1 = T_2 - T_1 = \frac{M_2 - M_1}{h'} = \frac{V \triangle x}{h'}$$

Substituting these values in the expression for f_s, there follows:

$$f_s = \frac{V}{bh'}$$

an expression valid, by the way, for the maximum unit horizontal shear (or vertical, of course) in any rectangular beam, whether of concrete or other material and for rectilinear or curvilinear stress distribution. The only difficulty in the application of this expression is in getting the value of h'. This value depends on the percentage of reinforcement, but for ordinary percentages and ordinary assumption as to stress distribution in the section, h' will differ but little from 0.875 h, where h is the depth of the beam to the center of gravity of the steel. In a homogeneous beam of depth d, h' is, of course, $\frac{7}{8}d$.

Similarly, for the unit adhesion, f_s, to the steel,

$$f_s = \frac{T_2 - T_1}{U \triangle x}$$

where U is the sum of the perimeters of all the rods resisting T. $T_2 - T_1$ is the force which must be resisted by adhesion in the section and $U \triangle x$ is the surface of steel available for the purpose. Putting in the value $\frac{V \triangle x}{h'}$ for $T_2 - T_1$, as before, there follows

$$f_s = \frac{V}{Uh'}.$$

For example, if, at a section of a beam where there are three 0.5-in. round rods 8 ins. below the surface, the shear is 7,000 lbs., the adhesive unit stress on those rods will be, taking the closely approximate value of h' given above,

$$f_s = \frac{7{,}000}{\frac{3\pi}{2} \times 0.875 \times 8} = \frac{1{,}000}{4.71} = 212.3 \text{ lbs. per sq. in.}$$

This deduction for f_s, it will be observed, is based upon the customary assumption of absence of tensile stresses in the concrete.

The results noted below were gained from beams 3 ins. wide, 9 ins. deep over all, and 8 ft. long. The steel reinforcement was 8 ins. from the top of the beam, and the amount in all cases was 1% of section above the steel. The rods included smooth round, cold-twisted square and Johnson corrugated. The Johnson rods were in all cases perfectly straight, but the others were some straight and some hooked up about 3 ins. at ends, and some of the smooth round rods had each end bent around a short piece of 1⅛-in. rod, which thus formed a somewhat loose anchor. In no case was there an anchorage plate or washer.

The loads were applied as shown in Fig. 2.

A slip sufficient to break an electric contact rang an alarm bell and the behavior of the rods as to slip was thus carefully watched.

Two grades of concrete were used; one was of proportions 1 : 2 : 2⅔, the stone being scaly trap; the other, 1 : 2½ : 5, the stone and sand being in this case of a character to permit a leaner mixture. The two grades will be referred to as rich and lean, respectively.

In all, 25 tests of this kind were made, 19 of them on rich beams and six on lean, and as might, perhaps, be expected, failure was due in every case to slip of the reinforcement, regardless of the kind of rod and the conditions of the end. Consequently the actual shearing strength of the concrete was never realized, and the values given are merely the value of the shearing stress in existence at the time when the adhesion gave out. In none of these 25 tests were there stirrups or diagonals or other web reinforcement.

The shear thus developed averaged, in the six tests of lean beams, 470 lbs. per sq. in., with extremes of 373 and 233; average age, 143 days; age of extreme values, 138 days for smaller, 137 days for larger.

The shear similarly developed in the 19 tests of rich beams averaged 628 lbs. per sq. in., with extremes of 750 and 488; average age, 50 days; age of 53 days for the higher value and 50 days for lower.

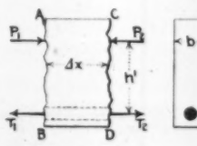


Fig. 1.

All of these values may, of course, be taken as horizontal or vertical shears indiscriminately. Considering that these values were in no case ultimate values, and considering that bending stresses were by no means excluded, these results add to the evidence now steadily and convincingly accumulating that the actual shearing strength of concrete has been greatly underestimated. They confirm the growing belief that failures have been attributed to shear that were due to slip of rods or diagonal tension, phenomena closely connected with shear, but still should not be called shear.

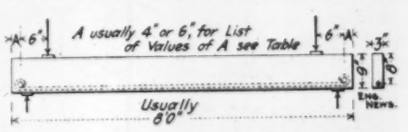


Fig. 2.

The adhesion stresses developed in the six tests of lean beams averaged 774 lbs. per sq. in., with extremes of 970 and 427 lbs. per sq. in. The 970 figure was for a perfectly straight unmodified cold-twisted rod in a beam 137 days old. The 427 for a similarly unmodified smooth round mild steel rod, this last a figure about twice what is usually expected of such rods.

In the rich beams the average of adhesion stresses in the 19 tests was 1,094 lbs. per sq. in., ranging from 913 for a smooth round mild steel rod with ends hooked up, through 960 for a similar rod without the hook, to 1,367 for a similar rod bent around a 1⅛-in. anchor rod as shown in Fig. 2.

The results in detail for lean and rich beams, together with the values of A (see Fig. 2) in each case, are shown in the accompanying table:

ADHESION UNIT VALUES IN REINFORCED CONCRETE BEAM TESTS.

Kind of rod and condition of end	Lean beams. *f_s lbs. per sq. in.	†A ins.	Rich beams. f_s lbs. per sq. in.	A ins.
Rods straight and unmodified:				
Smooth round mild steel...	427	4	.....	..
" " " " ...	...	..	960	7
" " " " ...	...	..	1,194	17
Johnson corrugated.....	...	..	1,182	7
"	...	..	1,232	9
Cold-twisted square.....	853	4	.....	..
" "	970	4	.....	..
" "	...	..	1,073	7
" "	...	..	1,155	9
" "	...	..	1,161	15¾
" "	...	..	940	12
Rods turned up at the end:				
Smooth round mild steel...	790	4	.....	..
" " " " ...	...	..	1,296	7½
" " " " ...	...	..	893	6
" " " " ...	...	..	913	6
Cold-twisted square.....	854	4	.....	..
" "	753	4	.....	..
" "	...	..	1,178	6
" "	...	..	1,185	6
" "	...	..	936	4
" "	...	..	1,102	6
Rods turned around a 1⅛-in. anchor rod (Fig. 2):				
Smooth round mild steel...	...	..	918	6
" " " " ...	...	..	988	6
" " " " ...	...	..	1,135	5½
" " " " ...	...	..	1,367	6

*f_s = Unit adhesion of steel to concrete.
†A — See Fig. 2.

Hardly less striking than the high adhesion values in all these tests are their comparative uniformity regardless of differences in types of rods and end conditions, and the unimportant difference between the results for smooth and deformed rods.

But it must not be forgotten that the conditions in these tests were of an extreme nature, and the inference must by no means yet be drawn that such high results are to be expected under other conditions of loading. These peculiar conditions may include something which would render the method of computing f_s inapplicable, but it is hard to suggest just what it could be. It would seem that such abnormally favorable action as might have been present in these tests would be equally likely to be present in an actual building under similar loading conditions. Possibly a vise action as result of compression of the concrete on the under side of the beam at the support due to the very high end reactions and consequent gripping of the rods may have been in operation, but if

FIG. 2. METHOD OF APPLYING JACKS IN MOVING CENTERING OF WALNUT LANE BRIDGE.

this had been the case one would hardly suppose there would have been so great a disparity between the results for the lean and the rich mixtures. The lean would be likely to deform more and lead to a tighter grip, but yet the results do not substantiate this view at all.

More plausible is the suggestion that even with this load, unfavorable as it was for producing deflection, the beams were sufficiently bent to interfere materially with slip. This, however, is a condition of practice, and nothing to invalidate the results from a practical point of view.

It should also be stated that with other and more usual conditions of loading, slip occurred with considerably lower values of f_s than the ones above given.

Whatever the value of adhesive stress actually developed in these 19 rich beams, the fact remains that the ultimate strength of the 9 of them which were reinforced with smooth round rods ranged from 4.5 to 6.5 times what our customary methods of figuring and ultimate stresses would have led us to expect.

And whether the adhesion stresses as given are correct or not, the 25 beams do afford a fair basis of comparison between the two mixtures of concrete as well as of the rods and their end conditions. What I have called the lean mixture is not believed to be an uncommonly lean one from the point of view of ordinary American practice, and that I have called rich is probably not so rich as the common European mixture as used by the best practitioners. Yet the difference between these two mixtures is striking. The rich concrete showed 42% higher average results for f_s than the lean, showed very much less variation from the mean, and furthermore were obtained at scarcely more than one-third the age. It is noticeable that the disparity between the smooth round rod and its rivals is vastly greater in the case of the lean concrete than in case of the rich, as was to be expected.

If arch action was the prevailing condition, the advantage in favor of the rich mixture is not so clear as otherwise because, with the rich mixture the A was almost always greater than with the lean.

The nearest recorded approach to these results for f_s, so far as I am informed, are those of Kleinlogel, described in "Beton u. Eisen," 1904, page 227. His beams were of 1 : 1 : 2 mixture, reinforced with smooth round rods absolutely unmodified or bent, without stirrups or mechanical anchorage. The span was 6 ft. 7 ins. and the beams were loaded at the quarter points. Size of beams was 6 × 12 ins. Age not clearly stated, but was not less than five months. His maximum f_s was 550 lbs. per sq. in. (an average of a set of four beams just alike), and was not an ultimate value, but like the shear values above recorded merely values realized when failure occurred some other way. The percentage of steel was 0.094. In Kleinlogel's case the failure was due to stretch of the steel between the supports and subsequent crushing of the concrete. The portion of the beams outside of the loads showed no sign of failure whatever and the adhesive strength had clearly not been reached. It is easy to believe if his beams had been loaded as were the ones in Cambridge, failure by bending would have been deferred until f_s reached as large values as those I have given. His maximum value of shear, f_s, was 470 lbs. per sq. in., and failure in this case was attributed to diagonal tension.

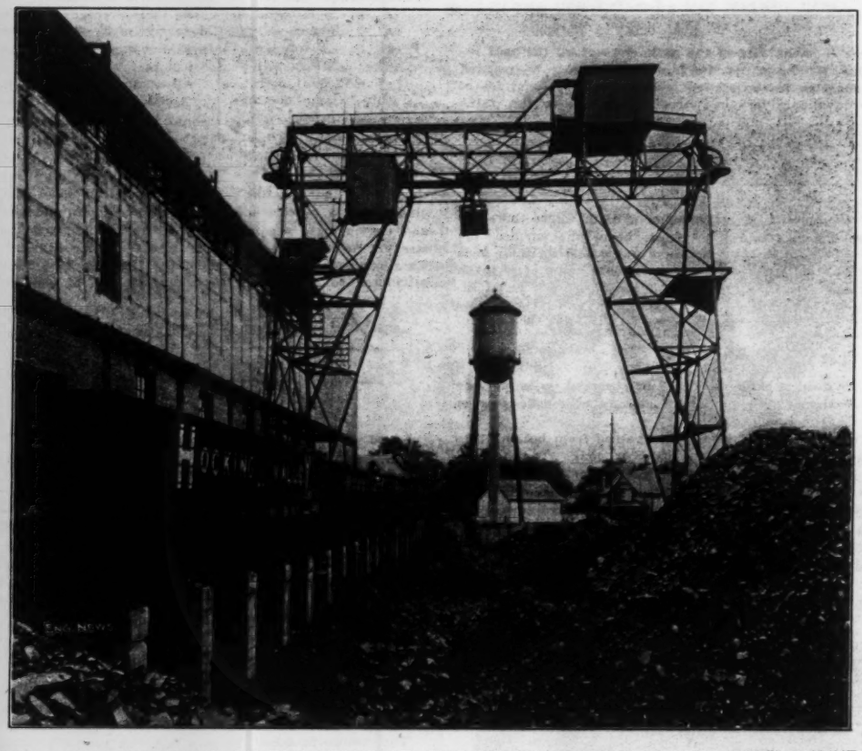


FIG 1. COAL HANDLING GANTRY CRANE AT THE POWER STATION OF THE FORT WAYNE & WABASH VALLEY TRACTION CO.

Kleinlogel attributes considerable importance to the deflected condition of the beam (carrying with it, of course, a slight bend in the rods) as increasing the f_s and, very properly I think, deprecates the customary attempt to reason from results from straight pulls of embedded rods out of blocks to the resisting power of a rod in actual service in a beam.

Professor Talbot's maximum value for unit adhesive stress upon smooth round mild steel rods in his series of 1905 was only 193 lbs. per sq. in., but this was not an ultimate value, for failure was to be attributed to causes other than slip. His loads were applied in a way not intended to develop extremely high values of V, while in the Cambridge beams just described of course high values of V were deliberately sought.

These very high values of adhesive stress and shear are presented for record and I cannot make it too clear that I believe the high adhesive results, at least, may be due, perhaps must be inseparably connected with, the very exceptional method of loading and should by no means be taken as a basis for design until further investigations are made. Either the results are valid as they appear, however, or there are circumstances in which the customary methods of figuring do not apply; if the latter, the reason is yet to be sought. The promising direction for the search, in my opinion, is arch action.

However all this may be, the tests certainly do encourage the hope that richer mixtures will remove much of our reasons for fear of adhesion or shear failu

COAL HANDLING PLANT OF THE FORT WAYNE & WABASH VALLEY TRACTION RY.

The electric interurban railway system of the Fort Wayne & Wabash Valley Traction Co. is supplied with current from a power station at Fort Wayne, Ind. The plant consists of seven Westinghouse-Parsons steam turbines, five of 1,500 KW. and one each of 500 and 400 KW. An unusual feature of the arrangement is that the turbines are placed on the second floor of the building, above the boiler room. The building is 50 × 180 ft. in plan, of brick construction, with reinforced concrete for the second floor and roof; the latter is carried by steel trusses.

One of the interesting features of the plant is the method of handling the coal supply. Parallel with one side of the power station is a coal storage basin, 50 × 180 ft. × 10 ft. deep below the level of the tracks. This is of concrete, with its floor shaped to drain away any water, and is spanned by a steel-frame gantry crane handling a grab bucket. Along the side of the building, and between it and the crane, is a concrete coal-bunker, 24 ft. above the ground and extending the full length of the building. Spouts from this feed the magazines of the automatic stokers. Eventually the pit or basin will be about 400 ft. long, with a storage capacity of about 10,000 tons. The bunker is of 600 ton capacity.

The gantry crane runs on a track of 60-ft. gage, and under one side of it is the coal car track, supported by piers within the pit. A one-ton Kiesler clamshell bucket is used, and the crane carries a McCaslin crusher. The bucket takes coal from the cars and delivers it to the hopper of the crusher or into the storage pit; or the bucket takes the coal from the pit and delivers it to the crusher, from which it is delivered by a chute to the bunker. The crane is moved along the track by two small electric motors, one at the foot of each leg, the speed of travel being about 60 ft. per min. The bucket is handled by a 65-HP. motor, giving a hoisting speed of 250 ft. per min. This plant easily handles 30 tons per hour, and has handled 50 tons per hour during an eight-hour shift. Ordinarily the crane man can operate the plant to its full capacity; but in coaling from gondola cars, a man is necessary in the car.

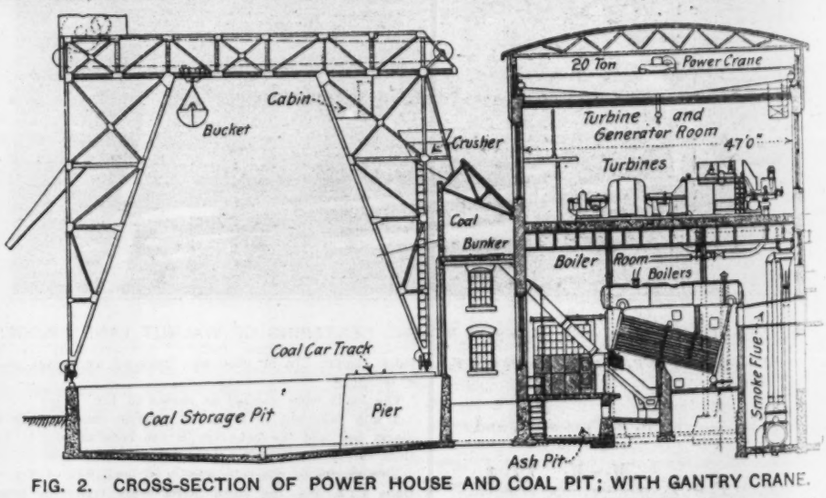


FIG. 2. CROSS-SECTION OF POWER HOUSE AND COAL PIT; WITH GANTRY CRANE.

Fig. 1 is a general view of the plant, with the coal track and elevated bunker at the left. On the left hand side of the crane will be seen the hopper and motor of the crusher, beneath which is a chute to the top of the bunker. Fig. 2 is a sectional elevation showing the arrangement of the power station and coal storage and handling plant. The coal-handling plant was built by Fairbanks, Morse & Co., of Chicago.

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The editorial "We" of one of our esteemed contemporaries really ought to be more careful of themselves. In the course of an editorial discussion they calmly state: "We have ourselves crawled for over a hundred feet" through a cavity between the street paving and a sewer. A whole editorial "We" aggregation should never be so rashly hazarded. A single sub-editor for important investigations and the printer's devil for ordinary subterranean explorations ought to satisfy the demands of the most exacting old subscriber.

The relations between employer and employee in certain branches of the mechanical trades in Great Britain should hereafter be of the most friendly nature if a recent agreement between the manufacturers and workmen is adhered to. This agreement was made between the Engineering Employers' Federation on the one side and the Amalgamated Society of Engineers, the United Machine-Workers' Association and the Steam-Engine Makers on the other, and supplants a previous agreement made in 1898. The terms of the compact show a disposition on both sides to be fair and equable, to uphold each its own rights but not to encroach upon the rights of the other. In case any trouble does occur special provision is made for arbitration. By the agreement employers are not to object to the existence of any trades unions within their personnel, but the members of such unions cannot prevent the employing of non-union workmen. On their part, the workmen have no valid ground for complaint if their firm joins any employers' association or, as it is more generally termed in England, federation. The management of such federations and unions is not to be interfered with, the one by the other. A trade union is to have the right to arrange a rate of pay under which its members may work, such rates to be made with due regard for the prevailing wages in each district, but no union can interfere with the rates of another branch of industry nor so conduct itself as to intimidate an employer into complying with demands made by another union.

These features of the treaty, if it may be properly so termed, aim to remedy the principal causes of dissension between employer and employed. The policy of non-interference in those affairs of the other side which are solely its personal concern, will not only prevent many attempts on the part of the union to direct the plans of the manufacturer but will also leave the workingmen free to regulate certain of their individual disturbances without the paternal direction of the employer destroying, in a way, their independence of action. The provision for employing non-union workmen is an acknowledgment of the principle of the "open shop" and an indication of the true liberty of both operator and worker. The last clause will tend to prevent what is, in the United States, at least, one of the most prevalent forms of labor trouble, the sympathetic strike. The average sympathetic strike is only a result of loyalty to the rules and orders of the union and is not due to any sympathy with the original cause of the trouble. If these rules are removed the workman will be only too glad to refrain from striking except when his immediate interests are at stake.

The agreement promises well and marks a great industrial advance over its predecessor of 1898, which showed a more hostile spirit on the part of each of the large interests concerned. Its operation should be watched by both capital and labor in this country.

The adhesion of steel to concrete is so indefinite a quantity and so important a question in the design of beams that numerous tests have been made to determine its unit value. These tests have generally been made by measuring the direct right line force necessary to pull an embedded rod from a block of concrete. Unit values so obtained are now used by designers in testing the adhesive strength of reinforcing rods in actual construction, computing such stress by any one of the many theoretical methods in use. It has been thought by many that this method of establishing unit values for adhesion is not consistent, for the reason that the direct tensile pull given may not fully represent the conditions acting to cause failure by adhesion in a loaded beam. The more rational way to determine the unit values would seem to be to test a beam so arranged that it must fail by lack of adhesion and then to calculate what unit stress caused that failure by the same methods used in computing such unit stresses in designing a beam for actual work.

We reprint elsewhere in this issue the results of a series of such tests recently completed by Prof. L. J. Johnson, of Harvard University. In these tests the loads were placed quite near the supports in order to ensure failure through either shear or rod slipping. In all the beam tests the rods slipped before shear failure occurred, so that the adhesion unit-stress was the critical one. The series was made on a limited number of specimens and under only one style of loading, and therefore is not conclusive as to the general case of a loaded beam. The consistency of the values obtained, however, makes the results of great importance as far as they go, and indicates the desirability of further tests along the same line, but with different forms of loading.

The remarkably high values attained are worthy of note. As Prof. Johnson remarks, this is doubtless due in a great measure to the manner of loading, which caused a gripping of the rods between the bed-plate and the concrete just above the supports. But even if 20% of the stress is due to this cause, the values are still greatly in excess of any heretofore reported. In his account of a series of tests in 1906, Mr. T. L. Condron (Eng. News, v. 56, p. 658) gave a résumé of all bond tests made up to that time, in which ten experimenters report unit adhesive values varying from 93 to 854 lbs. per sq. in. with an average of 515 lbs. per sq. in. The tests by Prof. Johnson give an average unit value of 1,020 lbs. per sq. in., varying from 427 to 1,367 lbs. per sq. in.

Although some of the bars in the tests under consideration were turned up at the ends, and some were anchored, the values for the straight rods are but slightly less than those for the deformed and turned-up bars. This is in contradiction to most previous tests and therefore additional data are needed before the higher values can be accepted in place of the former ones. In any case, the continuation and amplification of tests which are promised by Prof. Johnson will be looked forward to with interest.

The failure of the Erie Canal arch at Syracuse, N. Y., two weeks ago, carries about it an unpleasant suggestion, the suggestion of progressive deterioration, a wearing out, of stone masonry. Two-thirds of a century ago that arch was built, to be everlasting no doubt—at least the massive proportions and good materials indicate no idea of temporary construction. Yet now, after the lapse of only three conventional generations, the substantial stonework has broken out in a great hole, which quickly emptied a five-mile canal level of its water, with the result that the Empire State's famous water highway is most effectually cut across. The failure cannot be charged to increased loads (such as relegated our early bridges to the scrapheap), or to the effects of earthquake or other "Act of God," or to human interference (as careless excavation nearby). The arch went out with no apparent provocation, in regular service, in a dry summer season. Surely this is sufficiently abnormal to be startling. Are we to consider that a substantial piece of masonry is "old" at the scriptural threescore-and-ten years, and is then liable to the diseases and accidents of decrepitude?

Comfort from such a suggestion is readily found in the contemplation of a respectable collection of ancient, medieval and more recent constructions of both stone and brick masonry which stand to-day in robust condition. It is true that most of the master constructions of old have been defaced or wholly thrown down in ruins. Weather, vandalism, fire, perhaps also seismic action, are redoubtable enemies, able to strip the pyramids, destroy aqueducts, and lay waste monasteries. But many other of these structures remain, witnessing to the fact that good stone does not rot like wood or rust like iron and can stand unchanged through many men's lives, ever carrying its assigned load. Nor is this evidence offset by the history of constant crumbling, settling and elaborate repair that surrounds most of Europe's relics of medieval architecture. For in those cases there is usually present such diversity of origin, so much bad design and workmanship mixed with or patched on the good, in short such heterogeneity that progressive partial failure is almost a mathematical certainty from this alone, quite aside from the empiricism of the original architects and the ambitious boldness of their designs.

When the Campanile of St. Mark's in Venice collapsed, a few years ago, a sudden apprehension spread through Europe that other valued old structures would crumble into rubbish sooner or later. But as it became known what vital weaknesses had brought the Campanile to its fall—inadequate foundations, wretched brickwork, tie-timbers whose decay meant fatal weakening, and what not—these apprehensions were allayed. It was realized, and in fact had been realized long before in many quarters, that these old structures could be protected from progressive failure by proper reconstruction or other safeguarding of faulty portions as soon as the faults revealed themselves. Constant inspection by trained eyes, and prompt action on their findings, was recognized to be the first essential of protection.

A neat quotation appears on the first page of Professor Ira O. Baker's familiar "Treatise on Masonry Construction." It reads:

> The first cost of masonry should be its only cost. Though superstructures decay and drift away, though embankments should crumble and wash out, masonry should stand as one great mass of solid rock, firm and enduring.

This expresses a worthy ideal, no doubt; only an ideal, however, not a present fact. Now, it happens that to very large extent the condi-

tion which "should be," according to the words quoted, is unthinkingly assumed to be in actual and general existence. The idea of masonry is taken to include the idea of "firm and enduring" freedom from all current expense for inspection and maintenance. Is the engineer justified in such a view? Reasoning from a general standpoint, we may put the broad proposition that no construction of any kind is of such character that we are justified in dropping it from memory or attention, once it is completed. None is known to be free from the possibility, or better probability—or even certainty—of chronic or acute attack by forces that are numerous, varied and not all foreseeable. Looking aside from the slow disintegration of stone itself, which has been the cause of the ruin of many excellent masonry structures, or disintegration or leaching of the mortar, there yet remain such influences as for example the actions of unforeseen loads, the ceaseless action of differential expansion and contraction with temperature variation, the effect of vibrations induced from without, in a measure often depending largely upon the design of the structure itself, and more important than all others the changes in the foundation. The foundation, be it remembered, is as much a part of the structure as the coping-stone, and its changes affect the integrity of the whole as surely as would a loss of strength in the substance of the stone. And who will say that this or that structure—barring perhaps such as are built on sound rock well below the surface—has a foundation that can be relied upon as absolutely as the body of sound masonry? Surely, under the circumstances it is proper that masonry structures should be given inspection, from time to time, and preventive repair where needed, just as a steel viaduct is inspected, painted, adjusted and repaired!

The Erie Canal, fortunately, is amply provided for in the way of maintenance and inspection organization. Having its operating superintendents and its engineering forces, not hampered by lack of funds for proper maintenance, and accessible for fullest examination and repair during the winter half of the year when the water is drained out, the canal must be presumed to have more fully the benefit of the maintenance engineer's skill than most structures. This state of affairs should make it practically certain that the accident at Syracuse was not brought about by any of those causes which may be rendered harmless by regular trained inspection. Yet if this is the case, we are brought round again face to face with the picture of a substantial structure of masonry, less than seventy years old, going down in costly failure under regular service conditions, and in the absence of any extraordinary attack or emergency: not a pleasant picture. Fuller explanation of the collapse, which should soon be forthcoming, will therefore be a matter of strong interest, since it must tend to establish one or the other of these views, either that the collapse was wholly providential and unpreventable, or that the watchful care of those charged with its maintenance has not been sufficiently watchful.

SOME PLAIN FACTS AND OPINIONS ON MUNICIPAL OWNERSHIP.

The three-volume report on municipal ownership about to be issued as a result of eighteen months investigation by a committee created and financed by the National Civic Federation promises to contain a mass and variety of facts and opinions that would stagger any but the most devoted student of municipal ownership and perhaps confuse any but the most clear-headed student. And yet the fifteen hundred pages will contain much which, at least in essence, should be brought home to every intelligent citizen. For the sake of giving all interested a clear idea of the main conclusions drawn by the committee, unconfused by the details of the supporting evidence, and also to give publicity to those conclusions and to stimulate an interest in the full report, the Federation has issued an advance summary of the conclusions. This we print, substantially in full, elsewhere in this issue.

Perhaps the most remarkable thing about the conclusions is that 17 of 20 men chosen to represent all shades of opinion and a great variety of industrial and professional interests should have agreed on so many of the points involved in the municipal ownership controversy, and that two others, making 19 of the 20, were sufficiently in agreement with the majority to sign the report and content themselves with recording their points of dissent. These points, it is true, cover a majority of the most vital ones at issue, but there remain a considerable number of important points of agreement, some of which will not be relished by the narrower and more short-sighted adherents of private ownership. These two men are certainly to be commended for their evident desire to attain the broadest possible compromise agreement on the municipal ownership question. At the same time the probable fact should not be overlooked that some sacrifices in the interest of agreement must have been made by a number of members of the committee long known for their ardent and sincere belief in the completest possible program of municipal ownership.

The twentieth committee man, the report indicates, knows of no such words as compromise or concession. To him, municipal ownership is recognized, if at all, only as an evil to be put down. His single point of agreement with the majority (the 17) is that franchise companies should be subjected to public regulation, but even that, he hastens to add, should be "as far as possible automatic in its application and operation." How regulation could be made automatic the summary at hand does not indicate. It will surprise neither friend nor foe of municipal ownership to learn, if it has not already been suspected, that this uncompromising private ownership minority member of the committee hails from Philadelphia, and is a high officer in the United Gas Improvement Co., the famous lessee of the Philadelphia municipal gas works and the controlling genius of the private gas works of many other cities. It is also not surprising to learn that of the two dissenters from a number of vital points in the majority report one is president of the Edison Electric & Illuminating Co., of Boston, and the other is a prominent official in a large electrical manufacturing concern.

Before passing to a brief consideration of some of the conclusions of the report it may be well to call attention to the fact that while the majority of the committee got together on many important points, in its joint report, there is no lack of interesting disagreement in a number of the topical reports making up a considerable part of the forthcoming volumes. Such topics as the bearing of municipal ownership on the labor question, advance reports indicate, have been handled in a sort of joint debate fashion, pro and con. But with such ramifications we are not now concerned.

A brief summary of the points agreed on by 17 of the 20 committee men contains little on municipal ownership and franchise questions inconsistent with the attitude of this journal for many years past, as large numbers of our readers will see. Thus:

Municipal ownership is largely a matter of local expediency; fair comparisons between various cities cannot be made without taking local conditions into account; public utilities cannot be regulated in the public interest by competition alone, and if the public does not own or regulate them the companies will regulate if not own the public; public services of a sanitary nature, vitally affecting the public health, should be under municipal ownership; where private ownership prevails the cities should, for self-protection, and to ensure proper regulation, have the right to buy out the companies and set up municipal ownership; uniform accounts and statistics, with full publicity, should be required for all public utilities (evidently meaning regardless of ownership); where private ownership prevails the public should share in the growth of the profits, either directly or by a reduction of rates, and preferably by the latter; municipal ownership, to be successful, must be [illegible]orced from politics, and be put on a thorough[illegible] business basis; many American cities are [illegible]o-day unfit for municipal ownership.

Certainly there is nothing radical in [illegible] conclusions, and our summary contains at least a hint of nearly all the conclusions pres[illegible]d by the majority.

To some, perhaps the conclusions [illegible] seem tame, and hardly worth the effort inv[illegible]d in reaching them. Such a view, we think, [illegible]ld be a mistaken one. The inquiry would ha[illegible] been profitable had the committee found eve[illegible]ss to agree upon. After all the argumentation on this subject it is valuable to know what 17 men of so diversified training and affiliation can agree upon, and it is instructive to know to what extent men like Messrs. C. L. Edgar and W. J. Clark can agree with and must dissent from the 17, and to be assured, even if it were confidently expected, that a man with such affiliations as Mr. Walton Clark could agree to nothing that gave municipal ownership a foot to stand upon—or perhaps we should say a toe to cling by.

It is only fair to the two members who signed with but dissented in part from the majority to call attention to the fact that some of their dissent appears to be based on the report of the water-works expert; and it should be added that Mr. Walton Clark specifically bases some of his conclusions on that report. As Mr. Dabney H. Maury, M. Am. Soc. C. E., served the committee in this capacity, his report on this subject will be awaited with particular interest, especially by the people of Syracuse, Cleveland and Chicago, whose municipally-owned water-works were investigated by the committee.

We agree with the two dissenters that the sentence of the majority regarding the extension of municipal ownership to "revenue-producing industries which do not involve the public health," etc., is ambiguous. It is unfortunate and, in fact, unaccountable, that so confusing a sentence should have been published. At the same time, the dissenters may well be called to account for the uncertainty of the meaning of the first sentence of their last statement. We do not see that it means much unless it means that the popular vote on municipal ownership propositions should be so hedged about with restrictions that it will be likely to be negative. Perhaps the full report will make this clearer.

The conclusions as a whole should have a sobering effect upon both the friends and foes of municipal ownership. For the latter, they show anew how public opinion, here voiced by many well-informed, thoughtful men from various walks of life, is becoming more and more convinced of the necessity of regulating and controlling municipal franchise companies, and how even the more conservative element is ready to hold, and if need be use, municipal ownership as a club to bring private ownership to a sense of its duties to the public. But we are more concerned in emphasizing the lessons of the report for the friends of municipal ownership, and to these our few concluding remarks will be devoted.

While the majority sees no reason why municipal ownership should not be considered solely as a question of local expediency, and asserts, at least by inference, that it may be necessary as a defence against unfair private corporations, yet it suggests numerous safeguards against possible resulting evils, frankly admits that many American municipalities are unfit for municipal ownership and refers to the government of British cities in such a way as to suggest that we might profitably model after them in character and efficiency. If we are to have municipal ownership, with promise of real efficiency, the report plainly indicates, we must do much to reform our municipal government, we must put and keep competent men in charge of our public utilities, we must so finance these utilities that they will stand or fall on their own merits, and we must make radical reforms (although the report does not say just this) in our accounts and reports, reducing these (for publicly and privately-owned utilities alike) to a uniform and therefore a comparable basis. Such plain facts

and opinions as these, it seems to us, are the most significant features of the conclusions advanced by the majority of the committee, rather than are the arguments which they contain for or against municipal ownership.

LETTERS TO THE EDITOR.

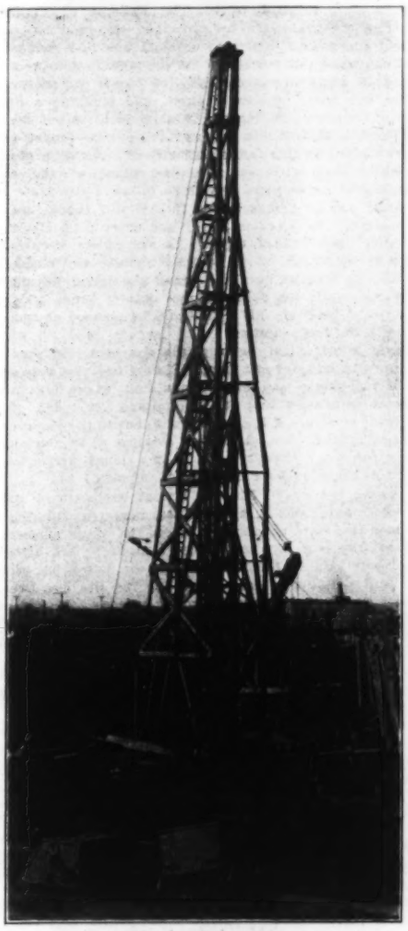
The Highest Pile-Driver?

Sir: In Engineering News, July 4, 1907, you published an article by Mr. C. E. Fowler, of Seattle, Wash., describing a pile-driver 99 ft. under the headblock. Mr. Fowler believed that this was the highest pile-driver ever built, and wished to learn if there were any others with longer leads. We have in use, on our Chalmette Slip construction, for the New Orleans Terminal Co., at New Orleans, La., a driver 108 ft. under the headblock with wheels, and 104 ft. with wheels removed and operating on rollers, the length of the leads being 101 ft. 1 in. under the headblock.

On this work we have had two floating drivers and seven land drivers. Accompanying this letter is a photograph of this driver, equipped with a boom and orange peel bucket, while it is being used in excavating earth from the trench; the hammer, of course, is removed.

Yours very truly,
James Stewart & Co.,
by J. H. Frederickson.

Hibernia Bank Building, New Orleans, July 29, 1907.



The Highest Pile-Driver?

Stresses in Gas-Holder Guide Frames.

Sir: I herewith present a diagram showing comparative stresses in the guide-frame of a single-lift gas-holder, with three different arrangements of guide-rollers. The arrangements are:

(1) With rollers acting radially against the posts in the corners of the polygon.

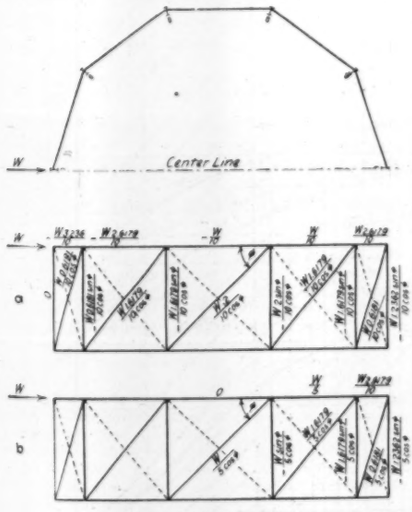
(2) With rollers acting radially and tangentially against the posts in the corners of the polygon.

(3) With rollers used in the guide-frame, as invented by Prof. H. Müller-Breslau. This construction has a special guide in the middle of each panel, attached to the horizontal girder and to a plate at a point where the diagonals intersect. The rollers are tangential rollers and act in a line parallel to the girders.

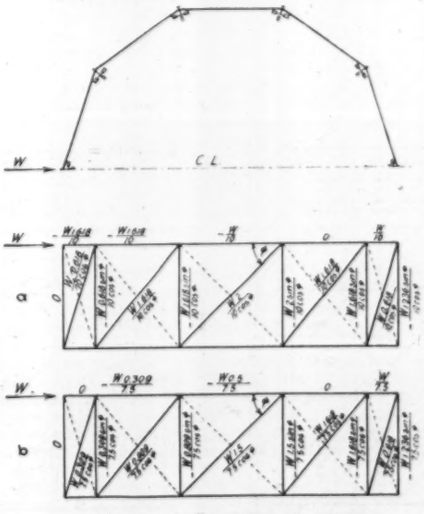
To compare the stresses in these different guide-frames a decagon guide-frame is used as an example. The wind load W is assumed to be horizontal, two sides of the polygon being parallel to the direction of the wind. The wind load *must* be transmitted to the frame by a rigidly constructed crown. The pressure of the wind will move the crown. The distance between crown and guide-frame will thereby be increased windwards and decreased leewards. The radial rollers will be very close to the guides on one side, while on the other side, they may not even touch them, a condition which is dependent on the pressure of the wind, on the shop work and on how close the rollers have been set to the posts at erection. For the determination of stresses, only a part of the radial rollers are supposed to be in action. Generally all the radial rollers of the leeward side, and the two adjoining rollers windwards, should be taken as acting. The construction of H. Müller-Breslau must necessarily be of great advantage over the radial type, since the tangential rollers are always in contact independent of the position of the crown, but his construction will not be of any advantage, as far as the amount of material is concerned, over the old system having a combination of radial and tangential rollers. Both of these latter constructions have been used for the building of very large gas-holders, and it would be hard to decide which is the more expedient.

The diagram gives the stresses in the guide-frame of a single-lift holder, as follows:

A—With radial rollers at the corners of the polygon.
a—All the radial rollers acting.
b—The radial rollers on leeward side only.



A- Radial Rollers.



B-Radial and Tangential Rollers.

B—With radial and tangential rollers at the corners of the polygon.
a—All the radial and tangential rollers, the latter with the exception of those which are perpendicular to direction of wind, are acting.
b—The radial rollers on leeward side and all the tangential rollers, with the exception of those which are perpendicular to the direction of wind in action.
C—With tangential rollers in the middle of each panel.

Yours truly,
H. Stoffels.

4216 Ivanhoe Ave., Norwood, Cincinnati, O., July 20, 1907.

Burning Sewage at Houston and in Larger Cities.

Sir: "The Independent" for July 25, 1907, page 198, in an appreciative article entitled "Government by Commission in Texas," states that

To-day the sewage of Houston is cremated three miles outside the city limits according to up-to-date sanitary plans of larger cities.

The casual reader might suppose that the word sewage had inadvertently been substituted for garbage did the context permit; the passage relative to sewage disposal, however, with numerous circumstantial details, plainly shows that sewage only is intended. It reads as follows:

A bond issue of $350,000 had been made by a former Council for placing the sewage outside the city limits, because the United States Government is making, at a cost of $4,000,000, a 25-ft. deep channel 150 ft. wide up Buffalo Bayou from Galveston to Houston (fifty miles), and the Government engineers required that the city sewage be first removed from Buffalo Bayou. This $350,000 was practically wasted by the old city government, and Houston had for the three years been paying interest on bonds that yielded no benefit. The Commission in the first year complied with the demands of the National Government, and an effective sewer system was put in, so that to-day the sewage of Houston is cremated three miles outside the city limits according to up-to-date sanitary plans of larger cities.

I suggest that you publish an account of the Houston plan of burning sewage, together with a list of the larger cities using the method, and if at the same time you can include a description of the manufacture of denatured alcohol from sewage and garbage whereby large profits accrue to a municipality, only vague rumors of which as yet occasionally come to us, you will show a commendable enterprise, and earn the gratitude of a large circle of your constant readers.

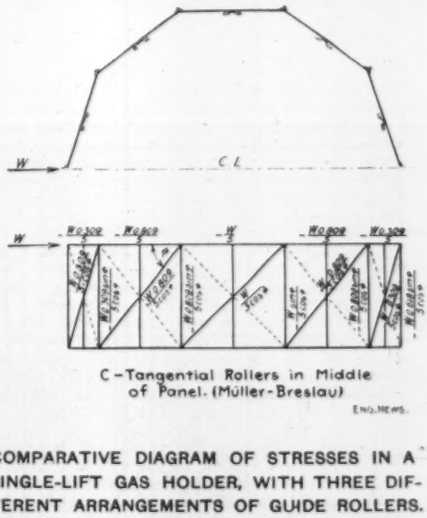
Respectfully,
Julian Griggs.

Columbus, O., July 29, 1907.

[Editors of daily newspapers frequently allow their story writers to burn sewage, but this is the first time, so far as we remember, that a well-edited weekly has done so. It seems to be incumbent upon the editor of "The Independent" to secure from the author of the article in question a list of the cities that are burning their sewage, and a statement as to how a substance which is 99% water is burned. Perhaps the other information desired by our correspondent could be secured at the same time and in the same way.—Ed.]

Anomalous Pile Resistance in Soft Mud; Effect of Hammer Shock.

Sir: I have read with interest Mr. J. W. Reno's letter in your issue of July 11 on "Pile Foundations in Soft Ground." Some years ago I had occasion to build a wharf in upper San Francisco Bay, and took considerable data on the pile driving. Let me state here that years ago, when hydraulic mining was permitted on the headwaters of the Sacramento and San Joaquin rivers, the finest and the lightest of the tailings were carried



C-Tangential Rollers in Middle of Panel. (Müller-Breslau)

ENG. NEWS.

COMPARATIVE DIAGRAM OF STRESSES IN A SINGLE-LIFT GAS HOLDER, WITH THREE DIFFERENT ARRANGEMENTS OF GUIDE ROLLERS.

to the very mouths of the rivers and formed the mud flats of the upper bay, which flats are so soft, and extend to such a depth, that except they be grown with tule no solid body can be supported by them. In taking data on the pile driving, I found that a pile would drop of its own weight to a depth of 20 to 27 ft. below mud level. Driven continuously, it would reach the position of its supporting power of 20 tons (by the formula

$$p = \frac{.023\ w \sqrt[s]{h}}{s+1}$$

at a depth of 40 to 55 ft. below mud level. If left at rest for 15 minutes, the heaviest blow would fail to move the pile, but after a few blows in rapid succession it would move again at a rate about equal to that at the last blow on the previous trial. It was attempted to drive a pile to refusal, and one of 110 ft. was used for the purpose. This was driven to water level, but in the time taken to splice, the mud had settled around it and it was impossible to move it further. I will add that after driving to a depth of 35 ft. it was found impossible to pull a pile with a scow of 30 tons displacement.

What I wish to bring out is this: I believe the mud of upper San Francisco bay (known as Suisun Bay) to be as fluid as any in North or East River, New York. I believe that piles driven to a depth of 60 ft. will have a skin friction of at least 20 tons per pile, exerted against both weight and buoyancy. This, for a 16-in. pile, gives a coefficient of friction of about 200 lbs. per square foot of surface, which agrees very closely with results in river silt in other localities.

To return to Mr. Reno's hypothesis of a cylinder in a viscous fluid: He states that the cylinder itself weighs but 7½ tons, while the piles are to be forced down till they have a resistance of 20 tons. If the tunnel were driven through solid earth or gravel, this would be practicable, but the particles being in suspension, so to speak, there would be a tendency to raise the cylinder. Now, suppose we use Mr. Reno's form of car, but instead of putting a hydraulic cylinder thereon we put a pair of runs and an ordinary steam hammer pile-driver, actuated by compressed air in place of steam; these piles could then be driven to the required depth without danger of changing the alinement of the cylinder.

Yours truly,

W. C. Hammatt,
Assoc. M. Am. Soc. C. E.

749 Laguna St., San Francisco, July 23, 1907.

An Engineer and Engineering Chances in Peru.

Sir: Since I came to Peru, I have had quite a number of letters making inquiry as to the chances for positions, salaries paid, and the general conditions of the country.

South America will undoubtedly be a fertile field for railroad engineers for many years to come. The building of railroads has scarcely commenced, and the possibilities of this country can hardly be expressed in figures. It is rich in minerals and agricultural lands, and the timber of the Amazon Valley is almost inexhaustible.

There are many projected railway lines, but I can speak only of Peru and the conditions that exist here. The Peruvian Corporation and the Cerro de Pasco Railway Co. control the railroads of Peru. Both companies have a large mileage projected, but when they will be built is largely conjecture. It is possible that location surveys may be started in a few months, but probably not until another dry season, which will begin in April.

The engineer that contemplates a trip to Peru expecting a "snap," had better stay in the States. It has been our good fortune, in one sense, to cover almost every condition of country from the Amazon to the Rio Grande, and, frankly, we are up against the hardest proposition yet found in railroad work. The swamps of Central America are preferable to the snow, rain and hail on top of the Andes. There is scarcely one in a hundred that can stand this elevation. At the present time we are living in camp at an elevation of 14,400 ft.; sleeping under five heavy woolen blankets, and breaking a half inch of ice every morning on the water pail. In one sense the food is abominable, simply because we cannot get fruit. Added to this is the difficulty of securing a cook, excepting the native *cholo*, a descendant of the old Incas. For generations they have followed one style of cooking, and no persuasion or threats will change them in one iota. It is grease, garlic and curry from Monday morning until Sunday night. As the native Peruvian, even of the upper class, is proof against any stomach trouble, he takes as kindly to grease and garlic as a duck to water, while the poor "gringo" has to suffer all the tortures of perdition. If fruit could be secured, it would simplify the food question.

There is not a leaf, or twig, the size of a lead pencil, within fifty miles of our camp. Simply one vast expanse of barren pampa and bleak mountains, whose tops are covered with snow that fell a thousand years ago. To the lover of nature it is simply grand, but to the engineer, locating railroads and eating and sleeping at an elevation above the top of Pike's Peak, it is a tough proposition and a fit place only for the hardiest of men.

I would advise the Brussels Carpet engineers to stay at home, but there is, and will be, many fine openings for men that have got the grit to live the life of pioneers. The salaries paid are, necessarily, from 25 to 50% higher than those paid for the same work in the States, but even this will not always compensate for the life one lives. Again, we would dissuade the young engineer, just out of college, from coming here, until he has become hardened to a rough life. There is not a single thing down here that is familiar to one born and educated in the States, excepting the "Big Dipper," and that is a mighty poor companion when one is alone, four thousand miles from home.

The difficulties to be encountered in railroad work are no greater than would be expected in any mountainous country, and the locating engineer has the advantage of being able to see all the physical conditions around him, as not so much as a twig grows on the mountains. His view is obstructed only by the mountain itself. As 20° curves and 3% grades are allowable it is an unusually difficult place where a line cannot be found to fit the ground, or one ought to say rocks, as there is very little ground on which to build.

The road that we will be engaged on will have at least forty miles of line in a canon, running from just above the high water mark to 500 and 1,000 ft. up on the side, where we cross to another drainage area. There will be a mile of line at a stretch where there is scarcely a foothold for a transit, much less for a man to stand.

Engineers anticipating work in Peru may ask what are the requirements in the way of clothing, etc. To this we would reply: For the top of the Andes, the same clothing and outfit that one would take if they were going to Canada for a winter's campaign. If they are going into the Amazon Valley then they need the same outfit as they would need in the swamps of Central America. One can find in Peru arctic cold, a[n] glaciers that would make the glaciers of the Alps look [cold], and he can also find swamps where the boa and 2[0] alligators are almost as thick as mosquitoes in [Southern] Texas.

For pastime, the camera will use 75 per cen[t] of the spare moments, and the remaining time can [be] profitably employed in a thousand ways. It is a coun[try] filled with interest from the moment that one lan[ds] until one leaves.

Naturally the health conditions above the 5,0[00] contour are as nearly perfect as can be found. P[neumonia] is about the only thing to fear. It is almost i[mpossible] that one coming to Cerro de Pasco have perfe[ct] lungs and heart. If possible, newcomers should be [put] into a room for 12 hours, and the air pressure re[duced] to the equivalent of 14,000-ft. elevation. Here th[ey] will be subjected to a far severer test than this, f[or] they will start at sea level in the morning, and at 2 p. m. they will pass over the Andes, 15,600 ft. elevat[ion]. As a rule, the big, strong athlete is a poor man on top of the Andes. The small, wiry man, with 4 ins. chest expansion, and a heart like an ox, can live here and enjoy the best of health, unless he is affected with catarrh; then he had better stay at a lower level. Heart, lungs and head must be perfect.

Wm. V. Alford,
Locating Engineer, Cerro de Pasco Ry. Co.

Camp Alcacocha, Oroya, Peru, June 23, 1907.

Diagrams for Earthwork Computation.

Sir: In Engineering News of July 6, 1905, page 18, "J. S. E." submitted a diagram, to natural scale, with curves giving volumes, in cubic yards per lineal foot, in trenches with vertical sides, and with given widths and depths.

The accompanying diagrams, *A* and *B*, indicate in outline the construction of *logarithmic* diagrams giving the

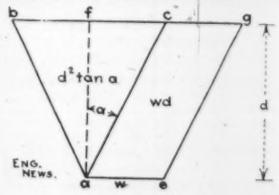


Fig. 1.

corresponding quantities in cuts (trenches) or fills *with different side slopes.*

In a "level section," Fig. 1, we have

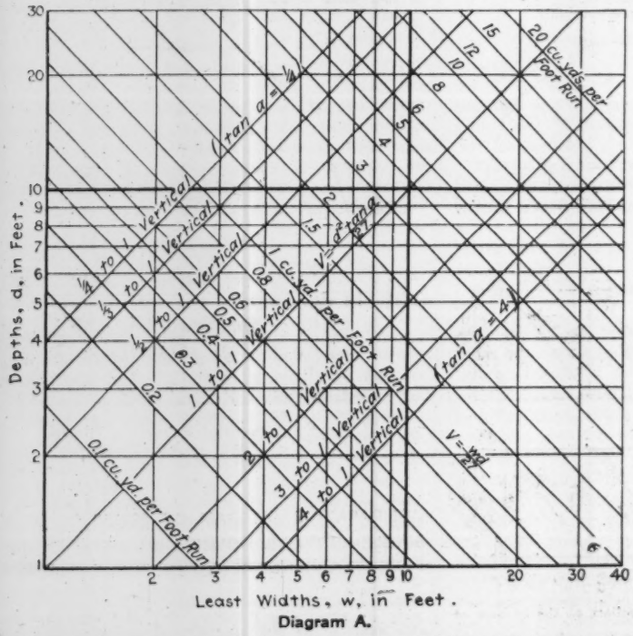
area = parallelogram, $c\,e$, + triangle, $a\,b\,c$;
$= w\,d + d^2 \tan a$;

where w = least width, d = depth, and a = the angle between the side slope and the vertical. When the sides are vertical, we have

$a = 0$, $\tan a = 0$, and area $= w\,d$.

The volumes, per foot-run, are of course proportional to the areas of the parallelogram and triangle. Thus

V = volume, in cubic yards per foot-run $= \frac{w\,d}{27} + \frac{d^2 \tan a}{27}$.


Depths, d, in Feet.
Least Widths, w, in Feet.
Diagram A.
1 to 1 Vertical.
2 to 1 Vertical.
3 to 1 Vertical.
4 to 1 Vertical.
1 cu. yd. per Foot Run
0.1 cu. yd. per Foot Run
20 cu. yds. per Foot Run
V = wd/27

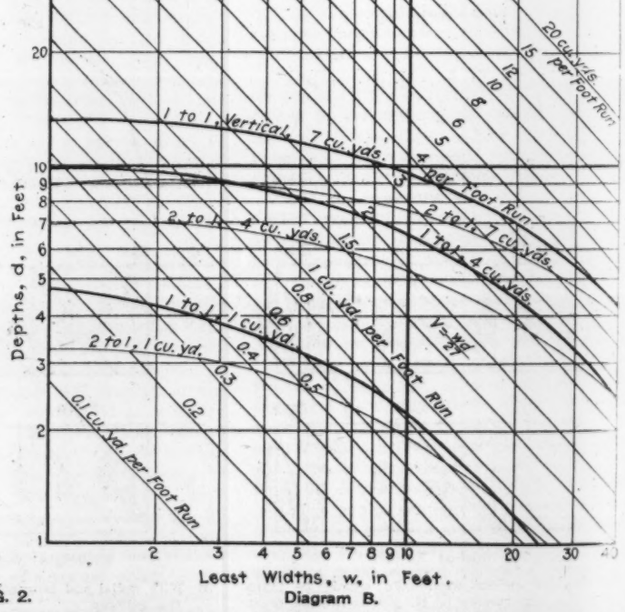

Depths, d, in Feet
Least Widths, w, in Feet.
Diagram B.
1 to 1, Vertical, 7 cu. yds.
2 to 1, 4 cu. yds.
2 to 1, 1 cu. yd.
1 to 1, 1 cu. yd.
1 cu. yd. per Foot Run
0.1 cu. yd. per Foot Run
20 cu. yds. per Foot Run
V = wd/27

FIG. 2.

In Diagram A, the lines sloping *downward* to the right give, in the first place, the values of $\frac{w\,d}{27}$. Thus, in a

trench with vertical sides, 3 ft. wide, 9 ft. deep, $V = \frac{w\,d}{27} \quad \frac{27}{27} = 1$; and we find that the vertical line on width 3 ft. meets the horizontal line from depth 9 ft. on the diagonal line marked 1 cu. yd.; and this is also the volume, V, corresponding to the area, $w\,d$, of the parallelogram, $c\,e$, Fig. 1, in a trench 3 ft. wide, 9 ft. deep, with sides at any slope.

In the same diagram, A, the lines sloping *upward* to the right give us, in connection with the other sloping lines, the quantity $\frac{d^2 \tan a}{27}$, corresponding to the triangle, $a\,b\,c$, Fig. 1, in trenches, etc., with sloping sides.

Thus, in a trench of any width, 9 ft. deep, with side slopes of 2 horizontal to 1 vertical ($\tan a = 2$), we have

$$\frac{d^2 \tan a}{27} = \frac{9^2 \times 2}{27} = \frac{162}{27} = 6;$$

and the sloping line marked "2 to 1 vert" intersects the horizontal line for the depth of 9 ft. on the diagonal line marked 6 cu. yds.

Having thus found (1) $\frac{w\,d}{27}$, and (2) $\frac{d^2 \tan a}{27}$, we add them together for the volume, V, of the entire trench, etc., in cubic yards per foot-run; for

$$V = \frac{w\,d}{27} + \frac{d^2 \tan a}{27}.$$

Diagram B (devised by Mr. Clinton L. Bogert, Assistant Engineer, Board of Water Supply, New York City), obviates the necessity of thus adding the two quantities together, and gives the entire volume, V, at one reading, this volume being read from the curves or from the straight diagonal lines, as the case may be (see examples below); but it requires a separate series of curves for each side slope represented in the diagram.

In Diagram B, herewith, I have drawn only six curves, viz.: those for 1, 4 and 7 cu. yds. per foot-run, each for side slopes of 1:1 vertical and 2:1 vertical. An actual chart would of course require many such curves; and, as these would intersect each other, some confusion might result. To avoid this, a separate diagram may be constructed for each value of the side slope.

Examples of the use of Diagram B; trenches 3 ft. wide, 9 ft. deep. In each case, find the intersection of vertical line on width 3 ft. with horizontal line on depth 9 ft.

(1) Sides vertical. ($\tan a = 0$). Here $V = \frac{w\,d}{27} = \frac{27}{27} = 1$; and, as in Diagram A, the intersection will be found on the diagonal line marked 1 cu. yd. per foot-run.

(2) Side slopes 1 horizontal to 1 vertical. ($\tan a = 1$.)

$$\text{Here } V = \frac{w\,d}{27} + \frac{d^2 \tan a}{27} = \frac{27}{27} + \frac{81}{27} = 1 + 3 = 4;$$

and the intersection is found on the curve marked "1:1 vertical, 4 cu. yds per foot-run."

(3) Side slopes 2 horizontal to 1 vertical. ($\tan a = 2$).

$$\text{Here } V = \frac{w\,d}{27} + \frac{d^2 \tan a}{27} = \frac{27}{27} + \frac{162}{27} = 1 + 6 = 7;$$

and the intersection is found on the curve marked "2 to 1 vert., 7 cu. yds. per foot-run."

In Diagram A, the lines sloping upward to the right, and indicating different side slopes, are parallel, and

line for ¼ to 1 vertical starts from 4 on axis of ordinates
line for ½ to 1 vertical starts from 2 on axis of ordinates
line for 1 to 1 vertical starts from 1 on axis of ordinates or abscissas
line for 2 to 1 vertical starts from 2 on axis of abscissas
line for 4 to 1 vertical starts from 4 on axis or abscissas,

and so on.

The diagrams may, of course, be used for obtaining the width, at any given height, the depth, or the slope, when the other two are given. In such cases, we solve the triangle $a\,b\,c$, Fig. 1 ($w = O$), by means of the diagram, and then make the necessary modification for the parallelogram, $c\,e$, with $w = a\,e$. Thus

Let d (= $a\,f$, Fig. 1) = 20 ft.; $f\,c = f\,b = 5$ ft., $b\,c$ = 10 ft.

Then side slope = 5 to 20 = ¼ to 1 vertical, and, in Diagram A, the vertical line, on $w = 5$ ft., meets the horizontal line, from $d = 20$ ft., on slope line ¼ to 1.

Conversely, given depth, d, = 20 ft., side slope ¼ to 1 vertical, the slope line marked ¼ to 1 vertical, meets the horizontal line from $d = 20$ on the vertical line standing on $w = 5$.

By moving the decimal point, the diagrams may be used for areas and volumes of any desired dimensions; but it must be borne in mind that if, for instance, both the width and the depth are increased 10 times, the cross-section areas, and the volumes per unit length, are increased 100 times. Other changes in the dimensions involve different changes in the areas and volumes.

In sloping ground, it will often be sufficiently accurate to consider the actual section replaced by a "level section" with d = the actual center depth. With width, w, = 160 ft., depth, d, = 60 ft., ground slopes 5 to 1, and side slopes 1 to 1, the error is only 5% in excess.

John C. Trautwine, Jr.
257 S. 4th St., Philadelphia, Pa., July 11, 1907.

NOTES FROM ENGINEERING SCHOOLS.

COLORADO SCHOOL OF MINES.—For the practical courses a mine is being opened about a half-mile west of Golden on the slope of Mt. Zion.

LEEDS UNIVERSITY, ENGLAND.—In the issue of Aug. 5, of the "American Gas Light Journal" appears an abstract of the courses in the new department of Fuel and Gas Engineering of Leeds University. The essential features of this prospectus are as follows:

Diplomas and Degree Courses.—(*a*) A diploma in gas engineering will be awarded to graduates of this or some approved university who, having graduated in science, with chemistry or engineering as a principal subject, shall have attended for 1 year the prescribed course for the third year of the Ordinary degree course, and have passed an examination thereon.

(*b*) The degree of B.Sc. with honors may, in gas engineering, be conferred upon students who, having obtained the diploma under the provisions of the preceding section, shall have spent an additional year in research in the department, to the satisfaction of the examiners.

SYLLABUS OF LECTURE COURSES:

(1) *The Physical and Chemical Properties of Gases* (*a*) Kinetic theory; fundamental gas laws; Van der Waal's equation; compressibility and liquefaction of gases; the critical state; specific heats; dissociation; diffusion and transpiration; viscosity of gases; flow of gases through pipes; modern theories as to the nature and conditions of chemical changes in gaseous systems; velocity of reaction; chemical equilibrium; influence of moisture and surface in gas reactions; occlusion of gases by metals and the action of gases upon solids generally; principles of thermo chemistry; gas calorimeters; heats of combustion of gases.

(*b*) The mechanism of combustion, etc.; slow combustion; ignition points of gaseous mixtures; flames and explosions; the explosion wave; rates of explosion; the combustion of carbon, carbon monoxide and cyanogen; the combustion of hydrogen and of hydrocarbons; the action of steam upon incandescent carbon; the reversible system: the action of CO upon metallic oxides; the thermal decomposition of hydrocarbons.

(*c*) Gas analysis and manipulation; preparation of pure gases; use of liquid air for purification purposes; fractionation of gas mixtures; collection and storage of gas samples; solubilities of gases in liquids; principles of gas analysis.

(2) *The Technology of Fuel.*—Introductory. The mechanical theory of heat; specific and latent heats; calorimetry; heats of combustion of fuels; pyrometry.

Coal and its combustion; natural gas; petroleum; shale oil and oil fuels generally; the manufacture of coke in by-product ovens; producer gas and its applications, including water gas.

(3) *By Product Coking Processes.*—A course of lectures will be given during the second term by a specially appointed outside lecturer who is connected with the industry.

(4) *The Manufacture and Distribution of Coal Gas.*—Arrangements are being made for the delivery of a special course of lectures on this subject by a well known gentleman connected with the industry.

(5) *Gas Lighting and Heating.*—The nature and structure of hydrocarbon flames; theories of luminosity; types of gas burners; the Bunsen burner; gas stoves; theory of the incandescent mantle; acetylene as an illuminant; photometry and spectrometry.

BIDS FOR THE ASHOKAN DAM for the additional water-supply of New York City ranged from $10,315,350 to $14,707,750. The specifications under which the bids were made were abstracted in our issue of Aug. 1, 1907, p. 112, while a map of the Ashokan reservoir and cross-sections of the main dam and embankment may be found in our issue of May 9, pp. 518-519. The five bidders, stated from lowest to highest (on basis of engineer's quantity estimate), were: John Pierce Co., MacArthur Bros.-Winston Co., Bradley Construction Co., Stewart-Kerbaugh-Shanley & Co., and O'Rourke Engineering & Construction Co., all of New York City. The unit-prices of the bids are given in full in the Construction News supplement of this issue, but we may profitably note here the prices set on some of the principal items of work: Earth excavation, per cu. yd.: Class A, $0.60-$1.50; Class B, 1.00-3.00; Class C, 0.30-1.00; Class D, 0.35-1.00. Rock excavation, per cu. yd.: Class A, $2.50-$5.00; Class B, 1.00-1.75; Class C, 1.00-2.00. Embanking and refilling, per cu. yd.: Class A, $0.42-$0.64; Class B, 0.375-0.65; Class C, 0.35-0.95; Class D, 0.50-1.50; Class E, 0.50-0.75. Portland cement: $1.50-$2.10 per bbl. Concrete masonry, per cu. yd.: $4.00-$5.60. Cyclopean masonry, per cu. yd.: Class A, $3.00-$4.10; Class B, 3.00-5.05. Concrete blocks, per cu. yd.: $5.05-$11.50. Face dressing of concrete, per sq. ft.: $0.10-$0.50. Dry rubble paving, per cu. yd.: $2.50-$4.15. The specified time of completion is 84 months.

THE SOUTH TUBE OF THE BELMONT TUNNEL under the East River, New York City, was completed on Aug. 7, the two shields meeting at "Man-o'-War's Reef." For a week previous the approaching sections had been connected by a small pipe, through which the workmen had conversed and by means of which the approach was gaged. The grade difference between the sections was only 0.04-in., and the lateral but a trifle over 1 in. Work was begun on the Belmont tunnel only a little over a year ago, and the two tubes have advanced at an average speed of 2 ft. per day. The north tube has been completed for two months, and it is said that experimental trains will shortly be run through it. The section of tunnel from the Grand Central Station to the river was constructed in 61 working days. Mr. St. John Clark, Chief Engineer, stated that both tubes can be ready for the operation of trains in three months; only existing difficulties over terminal arrangements at Long Island City—with real estate owners—will, it is said, delay the opening of service.

SPEED TRIALS of the first-class battleship "Connecticut," the first battleship of the class built at a Government shipyard, were made on Aug. 7 off Rockland, Me. In a series of 14 runs over a measured mile she averaged, for the best five runs, a speed of 18.73 knots. The "Louisiana," her sister ship—built by the Newport News Shipbuilding Co.—attained 18.59 knots as the average speed for her best five runs.

THE BATTLESHIP "KEARSARGE," which was recently placed in the new concrete dry-dock at the League Island Navy Yard to test the efficiency of the structure, left the dock on Aug. 8—the first battleship, it is said, to leave a dry-dock under its own steam and sail directly on a cruise.

A LARGE GRAVING DRY DOCK is soon to be built at San Francisco in connection with the two others now in operation in that section by the San Francisco Dry Dock Co. According to figures given in the discussion on dry docks at the International Engineering Congress at St. Louis, in 1904, this new dock will be the largest graving dock in the world. It is to be built mainly of reinforced concrete and will be founded on solid rock bottom. Its pumping plant will consist of four 54-in. centrifugal double suction pumps with a joint capacity of 200,000 gals. of water per min.; each pump to be driven by a 500-HP. three-phase induction motor. The leading dimensions of some of the other large graving docks now in use are given below, followed by corresponding dimensions for the projected dock at San Francisco:

	Length, ft.	Width, ft.	Depth, ft.
Liverpool; Canada dock	926	94	32
Bremerhaven	755	98	35
Birkenhead, No. 1	930	60	24
Gibraltar, No. 1	843	95	39
Newport News	841	103	30
Philadelphia, 1907	754	140	30
San Francisco	1,050	144	40

SPEED RUNS OF A 4-4-4 LOCOMOTIVE were recently made on the Bavarian State Railways, with satisfactory results. A train of 150 tons was hauled between Munich and Augsburg at an average speed of 80.6 miles per hour, while a maximum of 95.8 miles per hour was maintained for some time. The engine ran very steadily and had ample boiler capacity, although about 2,000 HP. was developed. An examination failed to show any particular effect upon the track. The above particulars are from a note in the "Schweizerische Bauzeitung." The engine was a four-cylinder balanced compound, with superheater, and was of the class illustrated and described in our issue of July 25, 1907.

TWO 300,000-VOLT TRANSFORMERS for testing were recently built by the General Electric Co., one for the Wirt Mfg. Co., of Plymouth, Mass., the other for the Power and Mining Department of the General Electric Co., at Schenectady. They are oil-insulated, and of the core type, the core consisting of two vertical legs joined at the top and bottom by horizontal yokes. The primary winding is placed directly on the core, and consists of one strip of copper wound in a single layer. The secondary is divided into 50 separately wound and insulated coils, having but one turn per layer in each; the 50 coils together have a total of about 16,000 turns. The insulation between layers and between turns of the end coils is reinforced so as to stand a continuously applied voltage of 10,000. The bushings for the high-tension leads are hollow cylinders filled with oil, a construction which has proved superior to solid material; in these transformers the bushings have been subjected to potentials of 500,000 volts for long periods without breaking down. The

characteristics of the transformers are: Frequency, 60 cycles; capacity, 300 KW.; primary voltage, 2,300-4,600; primary current, 65 amp.; secondary voltage, 300,000; secondary current, 1 amp.; full load efficiency, 97.4%.

A TANDEM-COMPOUND AIR COMPRESSOR with Corliss valves on both of the steam cylinders is a type of air-compressing plant that has recently been introduced. The purpose of the design is to obtain high steam economy in a machine of moderate price, and the machine is described as a tandem-compound, two-stage, Corliss straight-line compressor. The steam cylinders are on opposite sides of the fly-wheel shaft; they have two piston rods, one above and the other below the shaft. Behind the cylinders is the crosshead with the piston rod of the air-compressing end, and this also carries the connecting rods attached outside of the fly-wheels. The Corliss valve gears are operated by rods attached to a return crank at one end of the shaft, while the air-inlet valves are operated by rods similarly connected at the other end. The air cylinders have semi-rotary inlet valves, and automatic puppet discharge valves. This type of compressor has been designed by Mr. S. T. Nelson, one of the mechanical engineers of the Sullivan Machinery Co., and superintendent of the company's western plant at Chicago.

ARIZONA AS A COPPER-PRODUCING AREA is forging to the front among great areas of the world. In a preliminary statement issued by the U. S. Geological Survey, covering copper production in this country for 1906, Arizona's output exceeds that of Michigan by about 33,000,000 lbs., and is within 21,000,000 lbs. of that of Montana—the greatest copper district in the world. The figures for the three states are included in the accompanying table, which is arranged in the order of the productive importance of the states:

State.	Lbs. fine.	State	Lbs. fine.
Mont.	283,485,517	Nev.	1,090,635
Ariz.	262,566,103	N. C.	582,209
Mich.	229,695,730	Ore.	545,859
Utah	50,329,119	Wash.	290,823
Cal.	28,153,202	Wyo.	106,177
Tenn.	17,809,442	Mo.	54,347
Alaska	8,685,646	Tex.	51,377
Idaho	8,578,046	Ga.	17,182
Colo.	7,427,253	Vt.	11,694
N. Mex.	7,009,842	Mass.	9,744
Total			906,591,947 lbs. fine

Utah's position as fourth in the list is due to developments at Bingham. Developments in progress at Ely, Nev., should bring that state further up the list by another year. The total production for the United States for 1906 exceeds that for 1905 by about 18,000,000 lbs., or 2%.

ENLARGEMENT OF THE KIEL CANAL between the Baltic Sea and the North Sea is projected. The bottom width is to be increased from 72 ft. to 144 ft. (22 m. to 44 m.), and the depth from 29½ ft. (9 m.) to 36 ft. (11 m.). The enlargement prism is on one side of the existing channel, with substantially the same arrangement of side slopes (1 on 3 at the bottom, changing in several gradations to 1 on 1½ at the top) except that an 8-ft. berm 6½ ft. below mean water level is omitted. The width at mean water is increased from 220 ft. (67 m.) to 333 ft. (101.75 m.). Two new tidal locks are needed at either end, of dimensions 1,083 ft. long, 148 ft. wide, 45 ft. deep, 330 m. by 45 m. by 13.77 m.). Eleven passing points in the enlarged canal will replace eight present ones. Two swing-bridges are to be replaced by high-level bridges. The whole work is estimated to cost about $55,000,000. The enlargement is made necessary by the great increase of traffic through the canal. At the time of the first design, in 1886, a maximum annual traffic of 18,000 vessels, aggregating 5,500,000 register tons, was figured on. The traffic passed this mark in 1905, ten years after the canal opened, the figures then being 33,147 vessels of 5,750,000 register tons.

THE CHICAGO DRAINAGE CANAL extension for the water-power plant at Lockport has been completed, and water was admitted to the tail-race on Aug. 6. The earth dam at the lower end of the extension was blown out by dynamite in the presence of Mr. McCormick, President, and Mr. Wisner, Chief Engineer of the Drainage Board. The opening of the head race, admitting water to the power plant, will take place later, the city of Joliet having made some protest against this on the ground of alleged liability of damage in case of flood. The power developed will be utilized for street lighting in Chicago, and possibly in some of the towns along the canal. The plant (Engineering News, Jan. 18, 1906) is nearly completed, but no date has been set for putting it in operation.

PERSONALS.

Mr. R. E. Goodal has been made Superintendent of the Mystic Shrine mine at Bingham, Utah.

Mr. E. L. Herndon succeeds Mr. A. H. Beale as General Manager of the Eastern Steel Co., of Pottsville, Pa.

Mr. Marcell Mancard, Chief Engineer of the Filer & Stowell Co., of Milwaukee, has resigned and will become Superintendent of the Bolinders Engineering Works of Stockholm, Sweden.

Mr. Philippe D. Ahier, M. Am. Inst. M. E., has been appointed Manager of the Cariboo-McKinney gold mine, in British Columbia.

Mr. Thos. L. Livermore, Jr., M. Am. Inst. M. E., has resigned the general superintendency of the Cienequita Copper Co., Sonora, Mex.

Mr. John B. Pullian has been appointed General Manager of the Winnebago Traction Co., at Oshkosh, Wis. He succeeds Mr. E. B. Kirk.

Mr. W. C. Cram was appointed, on Aug. 1, Chief Engineer of the Randolph & Cumberland Ry. Co., in charge of maintenance of way and structures.

Prof. E. Brydone-Jack, formerly of the Chair of Civil Engineering at Dalhousie College, at Halifax, N. S., has accepted the corresponding Chair at the University of Manitoba, at Winnipeg.

Mr. W. D. Luscombe has been appointed Superintendent of Water-Works by the United States Steel Corporation, at Gary, Ind. He was formerly Superintendent of the Oskaloosa (Iowa) Water Co.

Mr. A. B. Nelson, of Trenton, N. J., Engineer of Construction for the Conestoga Traction Co., of Lancaster, Pa., has been appointed Chief Engineer of the Columbus (Miss.) Ry., Light & Power Co.

Mr. Wm. S. Mann, M. Am. Inst. M. E., has been made Manager of the Boston & Oaxaca mines at Tlacolulu, Oaxaca, Mex. Formerly he was Metallurgical and Cyanide Manager at the Montezuma mine at Miramar, Costa Rica.

Mr. Thomas Neilson, M. Am. Inst. M. E., has been appointed Metallurgist for the Shannon Copper Co., Clifton, Ariz. He was for a number of years Chemist and Metallurgist for the Mountain Copper Co., Martinez, Cal.

Mr. Walter Morehouse has been appointed Assistant Superintendent of Construction for the projected electric railway from Buffalo, N. Y., to Erie, Pa., suceeding Mr. A. S. Swank. Mr. Morehouse was formerly with the Cincinnati Northern Traction Co.

Mr. Wm. C. Madge, for several years Chief Engineer of Mill Construction for the American Smelters Securities Co., has resigned to open consulting offices at Salt Lake City. He will specialize in the design and construction of mining and ore-dressing plants.

Mr. Wilbur J. Watson, M. Am. Soc. C. E., has resigned his position as Bridge Engineer for the Osborn Engineering Co., Consulting Engineers, of Cleveland. Mr. Watson will engage in general contracting; no appointment has been made as yet to fill the vacancy which is made.

Mr. Ross E. Browne, M. Am. Inst. M. E., it is reported, will receive appointment as State Mineralogist of California upon the resignation of Mr. L. E. Aubury, at present holding the office. Mr. Browne has been professionally engaged for two years in the South African gold region.

Prof. Chas. H. Benjamin, who since 1889 has occupied the Chair of Mechanical Engineering at the Case School of Applied Science, at Cleveland, will succeed Prof. W. F. M. Goss as Dean of the School of Engineering at Purdue University (see this column for July 25). Prof. Benjamin is a graduate of the University of Maine, and during six years was instructor and Professor of Mechanical Engineering there.

Mr. Hammond V. Hayes, M. Am. Inst. E. E., has resigned as Chief Engineer of the American Telephone & Telegraph Co. Mr. J. J. Carty, M. Am. Inst. E. E., Chief Engineer of the New York Telephone Co., succeeds him. The engineering headquarters of the American Telephone & Telegraph Co. will remove from Boston to New York City.

Mr. Earle K. Knight, Assistant Engineer in the U. S. Reclamation Service, who was formerly in charge of construction of a division of the Garland Canal, Wyoming, has resigned and entered the service of the Department of Public Works of Cuba. Mr. Knight will be in charge of the construction work on the new $800,000 waterworks for the city of Camaguey.

Mr. Geo. F. Gifford has been appointed Chief Engineer of the firm of Milliken Bros., Inc., succeeding Mr. W. D. Batchelor, whose resignation we announced on July 18. Mr. Gifford was formerly a contracting engineer with the company; his appointment as Chief Engineer is the outcome of a decision by the receivers to enter into active competition in the structural field.

Mr. Arthur J. Cox, of Iowa City, Iowa, an alumnus of the Engineering Department of the State University of Iowa, has established an annual prize of $100 in the College of Applied Science of that institution, for the best thesis submitted for the first degree in engineering. The prize is to be known as the "Thomas J. Cox prize in Engineering," in memory of the father of the donor.

Mr. John C. Ostrup, M. Am. Soc. C. E., has been appointed to fill the Chair of Structural Engineering at the Stevens Institute of Technology, Hoboken, N. J. Prof. Ostrup is a graduate of the Polytechnic School of Copenhagen, later took a post graduate course at the Chicago Engineering School, and has had a large and varied experience in important work extending over 17 years. He was for five years in charge of office work and structural design for the Lake Street, the Northwestern and the Union Elevated Railroads of Chicago during their construction, and afterwards Designing Engineer for the Boston Elevated R. R. during its building. Upon completion he went into private practice for four years and has since during the past two years designed many important structures and bridges for the American Bridge Co. at New York.

ENGINEERING SOCIETIES.

COMING MEETINGS.

CANADIAN INSTITUTE OF ARCHITECTS.
Aug. 19-23. First annual meeting at Montreal. Secy., Alcide Chaussé, P. O. Box 259, Montreal.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 27-30. Annual convention at Chicago, Ill. Secy., W. O. Thompson, Oswego, N. Y.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
Sept. 10-12. Annual convention at Hot Springs, Va. Asst. Secy., S. C. Mumford, Detroit, Mich.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 10-13. Thirty-eighth annual convention at St. Paul, Minn. Secy., A. P. Dane, Reading, Mass.

LEAGUE OF AMERICAN MUNICIPALITIES.
Sept. 18-20. Eleventh annual convention at Norfolk, Va. Secy., John MacVicar, 18 Broadway, New York City.

NATIONAL IRRIGATION CONGRESS.
Sept. 23-28. Fifteenth annual convention at Sacramento, Cal.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Sept. 30-Oct. 4. Thirty-fifth annual meeting at Atlantic City, N. J. Secy., Dr. Chas. O. Probst, Columbus, Ohio.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Oct. 8. Annual meeting at Washington, D. C. Secy., Edw. A. Moseley, Interstate Commerce Commission, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION.
Oct. 8-10. Nineteenth annual convention at Atlanta, Ga. Secy., J. D. Farasey, Forest St. and Erie Ry., Cleveland, O.

AMERICAN STREET AND INTERURBAN RAILWAY ENGINEERING ASSOCIATION.
Oct. 14-16. Annual convention at Atlantic City, N. J. (See preceding item.) Secy., S. W. Mower, Southwestern Traction Co., London, Ont.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 14-18. Annual convention of this and affiliated associations at Atlantic City, N. J. Secy., Bernard V. Swenson, 29 West 39th St., New York City.

CANADIAN STREET RAILWAY ASSOCIATION.—At the recent meeting of the executive committee, held in Ottawa, Ont., the following officers were elected for the coming year: President, E. A. Evans, General Manager Quebec Ry., Light & Power Co.; Vice-President, J. E. Hutcheson, Superintendent and Purchasing Agent Ottawa Electric Ry. Executive Committee, D. McDonald, Manager Montreal Street Ry.; A. M. Grantham, Purchasing Agent Toronto Street Ry.; C. B. King, Manager London Street Ry. Counsel, A. H. Royce, President Toronto Suburban Ry.; Secretary-Treasurer Acton Barrows, Managing Director "Railway and Marine Review."

LEAGUE OF AMERICAN MUNICIPALITIES.—At the coming convention at Norfolk, Va., delegates will be entertained by the City. Subjects that will be discussed are: (1) "Municipal Government by Board (or Commission) as against that by Mayor and Council;" the success of the Commission form of government at Galveston, and that recently adopted for Des Moines, have attracted widespread attention, and the fact that several states have recently passed enabling acts permitting cities to adopt the Commission form of government has brought this question into prominence. (2) "Low Fares for Public Service vs. Franchise Taxation." (3) "Municipal Ownership." The list of speakers comprises leading students of municipal problems and officials of the prominent municipalities of the United States and Canada.

AMERICAN PUBLIC HEALTH ASSOCIATION.—At the coming meeting at Atlantic City, the following topics have been selected for discussion: (1) Milk; (2) Laboratory findings in diphtheria; (3) Immigration in its relation to public health; (4) What nuisances should be abated by the board of health; (5) Control of the so-called minor infectious diseases; (6) Vital statistics and the value thereof; (7) The construction and care of streets from a health standpoint.

The Marlborough-Blenheim will be headquarters for the Executive Committee. The Laboratory Section will hold a meeting on Monday, Sept. 30. The New Jersey Sanitary Association has arranged to hold its annual meeting at Atlantic City during the meeting of this association. The organization of a Section on Vital Statistics will be considered on Sept. 30 at the Marlborough-Blenheim. Dr. Edw. Guion, 1408 Atlantic Ave., Atlantic City, is Chairman of the Local Committee of Arrangements, and will furnish additional information.

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, August 15, 1907.

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EDITORIAL.

Two newcomers to the ranks of technical journals are to be noted this month.

The already well-filled German field has been entered by "Die Fördertechnik," under the editorial management of Mr. Max Wille. It is published semi-monthly at Berlin, and promises to report in detail on the construction and operation of pumps, blowing-engines, hoisting and conveying machinery and plants, presses and centrifugal machines. The first issue, dated July 1, 1907, contains an opening article on the development of tower cranes, and part of another serial article on the line of high-pressure centrifugal pumps built by a certain German firm. Several news notes, a patent review, book notes and an index of current articles in the technical press, occupy the rest of the issue.

Cuban engineering activity has led to the founding of a journal, "La Revista de Obras Publicas," a "technico-administrative" weekly devoted to all branches of engineering and to such administrative activities as are related to public works and public utilities. It begins its life with the first part of a discussion of technical education in Cuba, thus pointing very properly to the true beginning of a healthy and active development of engineering in the republic. The editors are Messrs. A. C. Vinageras, M. D. de Villegas and J. A. R. Garcia. The title of the new paper, unfortunately, is identical with that of a Spanish publication.

At the same time as the birth of these journals comes news of a rather radical innovation on the part of an old-established technical paper. The "Zeitschrift des Vereines Deutscher Ingenieure," the official organ and journal of transactions of the leading German technical society, is to enlarge its field by giving space regularly to the treatment and discussion of "economic and social questions." A resolution to this effect was passed at the recent annual meeting of the society, specifying further that the change be instituted with the beginning of the next year. A regular two-form supplement is to be inserted in the "Zeitschrift" to accommodate the new matter. A suggestion (though not a very clear one) of the field to be covered is given by the statement, contained in the resolution, that particular attention is to be bestowed on questions concerning technical economics, industrial management, colonial development, and social and sociological matters; questions of law, patents, education, and social organization, in their economic or industrial aspect; news and information about technical history; the relations between technical activity on the one hand and civilization and art on the other; and reviews of the current literature of these various subjects. This statement, if we have kept reasonably free from error in our translations, defines a field or a sphere of work so large, and so remote from ordinary engineering doings, that its inclusion in the scope of an engineering newspaper's concern is surprising, not to say startling. We are safe in saying that the results of the innovation will be looked for with some interest.

The National Fire Protection Association has begun the issue of a Quarterly, under the editorial direction of Mr. H. A. Fiske, Hartford, Conn. This, however, is merely putting a new dress on something already existing. Hitherto, quarterly bulletins, in pamphlet form, have been issued by the Association's committee on Special Hazards and Fire Record, in which were presented the details of instructive fires and related matter; and other pamphlets, circulars, etc., were issued at irregular times, as notices of the secretary, papers deemed worthy to be disseminated under the Association's auspices, and the like, partly with the cooperation of the National Board of Fire Underwriters. The new "Quarterly" is to bring all these publications together within one set of covers. Doubtless it will at the same time give opportunity for publishing many articles and news items of interest to fire-protection circles that under the old plan could not be thus brought before the members of the society. The leading features of the "Quarterly" are: an article entitled "Shirt, Collar and Cuff Factories and Laundries; Their Processes and Hazards," the second instalment of an extensive compilation on "Denatured Alcohol," and an opening paper on "The Cement Industry of the United States." The remaining matter includes fire records, editorial notes, and various news items. The new publication has an opportunity for very useful and effective work, and can extend very greatly the influence and effectiveness of the National Fire Protection Association.

REVIEWS.

A New Edition of Byrne's Highway Construction.

Reviewed by S. WHINERY,* M. Am. Soc. C. E.

A TREATISE ON HIGHWAY CONSTRUCTION.—Designed as a Text-book and Work of Reference for All Who May Be Engaged in the Location, Construction, or Maintenance of Roads, Streets and Pavements. By Austin T. Byrne, C. E. Fifth revised and enlarged edition. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5⅝ × 9¼ ins.; pp. xiiii. + 1,024; 300 illustrations in the text and 92 tables. $5.

The general scheme of this book is stated in the preface to the first edition, issued in 1892, as follows:

> Although volumes have been written on the subject of highway construction, still the matter is widely scattered through the pages of the standard works on engineering, technical journals and periodicals, in pamphlets and reports of city engineers, and is, therefore, not always easily accessible when wanted.
>
> The author, having found the need of a comprehensive and practical work of reference upon the many subjects connected with highways, has in the following pages endeavored to collate the varied mass of information.

In the succeeding editions, of which this is the fourth, much additional matter has been added, and an attempt apparently made to keep the book abreast of the times.

Within the special field covered the work may be said to be cyclopedic in character. It aims to cover pretty much all the data available on roads and pavements.

The reader will find a vast quantity of interesting information within the 929 pages of reading matter, inclusive of more than 100 tables. No branch or subdivision of his subject has been neglected by the author.

The historical sketch with which the book opens contains much interesting matter, but it is not as complete as would be desirable. It is particularly deficient upon the history of street-paving in the United States, but it should be remembered that the data for any satisfactory history of this kind are scarce and difficult to get. The historical notes in Mr. Tillson's "Pavements and Paving Materials" will be found much fuller and more satisfactory by the student in this field.

Chapter I. is devoted to a general discussion of the qualities requisite for a good roadway pavement, the cost of transportation by roadway vehicles, and a comparison of the merits of the several kinds of pavement now in use. The treatment of this branch of the subject is quite full, and there is an evident purpose to be fair and just in stating the comparative economy and desirability, from various points of view of the different kinds of pavement.

Chapter II. is devoted to the materials used in the construction of pavements and roads. The localities where these materials are found or produced, their physical and chemical properties, their durability, and the methods and apparatus used for testing them, are quite fully and satisfactorily described and discussed. While a few inaccuracies are noted, this is, upon the whole, one of the most complete and valuable compilations of data on paving materials in our language. The chapter occupies 103 pages and the matter is presented in a very concise and logical manner.

Chapters III. to VII., inclusive, are devoted to stone pavements, wood pavement, asphaltum and coal tar pavement, brick pavements and broken stone pavements—a chapter to each—and as these five chapters occupy 220 pages of the book, it will be appreciated that the author has treated this branch of his subject quite exhaustively. Chapter VIII. treats briefly of miscellaneous pavements, some of them more or less experimental in character, and but few of which are largely used. Some of them are interesting only as examples of the ingenuity and quixotic ideas of novices in this department of municipal engineering.

Chapter IX. relates to foundations for pavements. This chapter, while containing a large amount of information and much sound doctrine, must be read with some caution by the student, as will be pointed out later on. Chapter X. is devoted to the subject of resistance to traction on pavements and roads and the theory and experimental results are presented in a complete and satisfactory manner. Chapters XI. to XV., with Chapter XVIII. and parts of other chapters, present quite a complete and valuable treatise of more than 150 pages on the location, construction and maintenance of roads.

There is a chapter devoted to city streets as distinguished from country roads; a chapter upon the repairing, cleansing and watering of roads and pavements; one devoted to the planting and care of trees along roads and streets, and one upon Implements and Prices, which is quite full and valuable.

Chapter XXII. is devoted to specifications and contracts. The reader, whether he be a student, a practicing engineer or a city official, will find this chapter worth careful perusal. The author's definition of a satisfactory contract is worth quoting:

> A good, clear and comprehensive contract is a difficult thing to write, but it should be "common sense" from beginning to end, and should be the joint production of both engineering and legal ability, neither sacrificing the one feature to the other.

A final chapter on "Miscellaneous Notes" contains a large quantity of useful information not otherwise classified, together with some additional or more recent information on subjects previously treated.

In the table of contents four Appendices, to occupy 16 pages, are scheduled to follow the regular chapters; but these seem to be omitted from the book—to the regret of the prospective reader, for the titles of these appendices indicate that they would be interesting and valuable.

The illustrations throughout the book are very numerous—over 300 in number. They are well

*Consulting Engineer, 95 Liberty St., New York City.

selected and clearly printed. The typographical work on the book is above criticism. One of the most praiseworthy features of the work is the very complete and well-arranged index, covering 93 pages, and making it easy to refer to even the smallest detail of the voluminous contents of the book.

It seems ungracious to criticize adversely a book which, upon the whole, is so meritorious; but the candid reviewer cannot overlook glaring faults and imperfections, particularly if these are of such a character as to be likely to mislead the general reader and those engineers who may not be especially familiar with the subject. Unfortunately there is much of this character in this book that cannot be passed over in silence.

The first edition of the work appeared in 1892. Since that date the art and science of road and pavement construction has made many strides forward. So great has been the advance and so widely has practice and opinion changed in the meantime that a book, regarded then as up to date, would have to be largely rewritten to make it conform to the theory and practice of the present. While the author has added much new material and rewritten a considerable part of the text, the great body of it remains as in the original edition. The result is that the book is full of anachronisms and antiquated statements, and the reader may be unable to separate the ancient from the modern. Some instances may be given: In the chapter on foundations, the text relating to concrete (pages 385 to 428) cannot be accepted as satisfactory at the present time. In referring to the composition of concrete (p. 387, art. 463), the author states:

> The addition of water must be limited to the actual requirements, which fluctuate for natural cements between 50 and 55%, and for Portland cement between 40 and 45% of the weight of cement used. Plasticity is only to be attained by diligently tamping an apparently dry mass until water appears on the surface.

The older class of engineers very well remember a time when this was considered sound doctrine; but it is not so regarded to-day. Again (Art. 476, p. 395), under the heading "Characteristics of Portland Cement," it is said:

> The fineness should be such that 80% will pass through a sieve of 2,500 meshes per sq. in. * * *
> When moulded into a briquette and placed in water for seven days, it should be capable of resisting a tensile strain of from 300 to 400 lbs. per sq. in. [neat cement being referred to.] * * *
> A pat made with the minimum amount of water should set in not less than three hours nor take more than six hours.

When it is remembered that the present edition of the book bears the date, April, 1907, and that the standard specifications for Portland cement adopted by the American Society for Testing Materials were published two years before that date, it seems strange that these specifications were not substituted for the above antiquated "characteristics."

The abstracts from specifications for concrete are nearly all so old as to be no longer of much value. In fact, this remark applies to a large number of the specifications quoted throughout the book, and the author has not even taken the precaution to give the date of their adoption or use.

In the chapter on the repairing, cleansing and watering of streets are found (p. 708) a few brief paragraphs about the methods and statistics of street cleaning in the City of New York. The reader would naturally infer that the statements refer to the present time, or at least to recent years. They actually relate, however, to a period long since historical, and are largely untrue of present conditions.

Examples of this serious fault might be multiplied almost without limit, and they detract very much from the value of the book. If it were found impracticable to rewrite such misleading statements, the insertion of dates would have lessened the mischief they are liable to do among general readers.

Another class of faults should be referred to. Parts, at least, of the book give one the impression that they have been written hastily and with too little regard for the precision of statement one naturally expects in engineering books; and the qualifications necessary to make statements of fact accurate and reliable are often wanting. For instance, it is not made sufficiently clear that beyond a common name and the use of a natural bituminous cement, European and American asphalt pavements are practically different kinds of pavement. The tractive resistance of the European pavements (determined by early and doubtful experiments) is used throughout the book as representative of asphalt pavements in general; whereas, the truth is, that the tractive resistance of the American asphalt pavement, as now constructed, is much greater than the figures given. The results of the more recent determinations in this country were undoubtedly accessible to the author, and should not have been neglected.

So also in the matter of the relative slipperiness of pavements, data derived from the European asphalt pavements are wholly inapplicable to American asphalt pavements.

The statement on page 10 that "The only measure of the durability of a pavement *is the amount of traffic tonnage it will bear before it becomes so worn that the cost of replacing it is less than the expense incurred by its use*," would be quite true if it did not ignore the element of natural decay, which is often controlling.

"From measurements made by the engineers of France it appears that about 7 cu. yds. of material per mile per annum are removed from the road surface by the action of wind and water." This statement would be, in the printer's parlance, "good stuff," if the character of the roads from which the data were derived was given.

The statement (p. 121) that "It is doubtful if creosoting, etc., adds to the life of wood employed for paving" would be more accurate if the words "ability to resist travel" were substituted for "life," and the sentence would doubtless then express what the author meant to say.

It is hardly fair to the general reader and to the engineer who may not be conversant with the facts to quote the strong denunciation of wood pavements, on sanitary grounds, by the health officer of Detroit, without explaining that at the time the opinion was written untreated wood pavements, only, were in use in that city. Dr. Wight would doubtless modify his opinion materially, now that creosoted blocks are coming into use, or would, at least, except the latter from his sweeping condemnation.

Further examples of this kind are plentiful, but are not needed to illustrate the criticism.

The reader will also frequently meet with statements which seem to be erroneous in fact, or not in accordance with accepted practice, either present or past. A few such follow:

Page 67. "By comparatively simple operations the several varieties of asphaltum may be reduced to an equal state of purity." This is certainly not true with reference to the two leading varieties of asphalt in use, Trinidad and Bermudez.

Page 81. "To the presence of these salts [enumerated in the preceding paragraph] is due the rapid disintegration of the asphalt under the action of water and moisture, as seen in the gutters, etc." This idea was never more than a theoretical assumption, long since proved untrue by direct experiments.

On page 110, among the "characteristics of brick suitable for paving," is given: "(2) not to absorb more than 1-600 of its weight of water in 48 hours." This may be a typographical error which escaped the proof-reader; but the young engineer or the city official who might put such a requirement into his specifications would get into serious trouble.

On page 198 it is stated as an objection to asphalt pavement: "It is not adapted to grades steeper than 2½%," though this dictum is discredited in the paragraph that immediately follows.

In speaking of pavement foundations (page 383) it is stated that

> Clay should be excavated to a depth of at least 18 ins. below the surface of the finished covering and the space so excavated filled in with sand, furnace-slag, ashes, coal-dust, oyster-shells, broken brick, or other materials which are not excessively absorbent of water.

Authority for this statement is certainly not derived from the best American practice.

It seems a great pity that a book designed to be a vade-mecum, and otherwise so admirable, should be marred by such faults. Purporting as it does to be "designed as a text-book and work of reference for all who may be engaged in the location, construction and maintenance of roads, streets and pavements," it seems proper that some of its delinquencies should be referred to by the reviewer in order that the incautious reader may not be misled.

Nevertheless it is a book that should be in the library of every municipal engineer.

SHAFT SINKING IN DIFFICULT CASES.—By J. Riemer. Translated from the German by J. W. Brough, Assoc. M. Inst., C. E. London, England: Charles Griffin & Co. Philadelphia: J. B. Lippincott Co. Cloth; 6 × 9¼ ins.; pp. 122; 19 folding plates and 18 text illustrations. $3.50, net.

The mining man, in undertaking to develop properties where the lay of the ore bodies is such as to necessitate sinking, occasionally finds himself confronted by conditions of the overlying ground which preclude the ordinary pick-and-shovel method of excavation and timbering. It may be a quicksand, or it may be that extraordinary amounts and pressure of water prohibit usual methods.

It is to such difficult conditions that this work is specifically devoted. The author has handled his subject by selecting existing workings where such conditions have been encountered—mainly in Germany—and describing clearly and illustrating the methods that have been there employed.

The book is divided into four main sections, devoted respectively to (1) Shaft Sinking by Hand, (2) Shaft Sinking by Boring, (3) The Freezing Method, and (4) The Sinking Drum Process. Concrete examples are given of the application of each method.

The folding plates in the back of the book amply illustrate the constructive details involved, to those who may wish to make practical application of the methods presented.

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Pavement Specifications.

Reviewed by EDWIN A. FISHER.*

SPECIFICATIONS FOR STREET ROADWAY PAVEMENTS.—By S. Whinery, M. Am. Soc. C. E. New York: The Engineering News Publishing Co. Paper; 6 × 9 ins.; pp. 56. 50 cts., net.

The large and successful experience of the author in the construction of pavements, and his studious habits and careful use of language, make any article he may write upon the subject of especial interest. The reviewer has a pleasant recollection of the careful and painstaking work done by the paving company of which the author was for many years chief engineer and general manager, and he can appreciate the candor and fairness with which he deals with the subject of contracts and contractors; treating them the same as men engaged in other legitimate business.

The author's conclusions respecting guarantees, found on page 6, taken in connection with the form of the guarantee of work and material, found in paragraph 108, page 54, and paragraph 111, page 55, should meet with general approval both by municipalities and contractors. The same idea is intended to be expressed in many specifications now in use, but in none with which the writer is familiar is it so clearly set forth. The paragraph, however, is open to the objection that too much is left to the opinion of the engineer. So far as practicable the condition of the pavement at the end of the guaranty term should be so fully described that the defects due to improper work or material might be definitely determined.

The paragraph on page 11, stating that the payment of any compensation, or the giving of any gratuity, by the contractor to any inspector, is prohibited, seems to be entirely unnecessary. The reviewer believes there is no excuse for any misconception of the position of the city, or of the engineer, upon this point, and that any clause forbidding an act so manifestly wrong on its face weakens rather than strengthens that position.

Paragraph 21, page 14, headed "Extra Work," should be amplified, as the extra work required is at times difficult to fix a price upon in advance. The reviewer's specification is as follows:

> No extra work will be paid for unless it is done upon the written order of the City Engineer, and any work done upon said written order and for which no price is made in this agreement, or fixed by agreement between the Contractor and Engineer, shall be estimated by the City Engineer at its reasonable cost, which cost shall as far as practicable, be based upon the prices bid for similar work under this contract.
>
> In case the Engineer deems it impracticable to estimate said extra work as aforesaid, the Contractor shall present an itemized account of the labor and material used in said extra work, which account must be verified by the Inspector on the work; and said Contractor shall be paid the actual cost, together with 15% of his pay-roll additional for supervision and use of tools. Claims for extra work must be presented to the Engineer on or before the 10th day of the month following that in which said extra work is done.

The reviewer agrees with the author with reference to the pavement foundation, as described in paragraph 24, page 15, and the foot-note. It is a source of satisfaction to the reviewer that although the property-owners on a large number of streets in Rochester have urged that the old pavement should be used for the foundation of the new pavement, and have referred to what was being done in New York and other cities, yet he has been able to prevent work of this kind, and has succeeded in having new concrete foundations laid in every case.

Referring to the ratio of concrete materials, paragraph 31, page 18, and foot note, the reviewer believes that a concrete made up of 1 part cement, 3 of sand and 6 of broken stone is not too rich a material for all kinds of streets. It is undesirable to have too many different specifications used by the same contractor for similar work. It was formerly the practice to use natural cement for some parts of the work, and while concrete made in this way is satisfactory for setting curb, and for many other purposes, it is exceedingly undesirable to have different kinds of cement on the same piece of work.

In Rochester and in some other cities it is the practice to provide for all underground work in advance of the pavement, and to examine gas pipes, water pipes and any other underground structures before covering them with the new pavement. This practice results in digging up a large portion of the street (just prior to paving), and while the contract specifies that the backfilling shall be thoroughly tamped and consolidated, there will be many places where it will be uneven, and whether the pavement will be laid on a street of heavy traffic or light traffic, the concrete should be of sufficient strength to bridge over slight settlements. It has been the custom, therefore, to make no concrete foundation in streets so treated of less than 6 ins. in thickness, and in case of very heavy traffic streets with an unusual amount of filled ground, to increase this thickness.

As the matter of backfilling of trenches is one of the most important parts of street construction, where the underground work is put in under the same contract as the pavement, it is to be regretted that the author has not given a detailed specification of how this work should be done. The company with which he was formerly connected did very satisfactory work along this line, and so far as the reviewer knows there has been no settlement of pavements constructed by that company on account of defective backfilling.

The reviewer believes that the composition of the base course for sheet asphalt recommended by the author is better adapted for its purpose than any heretofore used. The first asphalt pavements laid in Rochester were laid with a ½-in. cushion coat of the same material as the 2-in. surface coat, making a total thickness of 2½ ins. Still later, the base course, or binder, was used, and is now.

Street Railroad Tracks (paragraph 56, page 32), referring to laying asphalt surface directly against the rails, and foot note: The reviewer has experimented with all methods of connecting asphalt pavement to the pavement in street railway tracks, and believes that there is no better way than to lay the asphalt pavement directly against the rail, provided the rail itself is a heavy girder rail of not less than 90 lbs. per yd. in weight, and supported upon an unyielding concrete foundation. In case the track is not laid upon a solid foundation, or in case the rail is not of the heavy street railway type, the most satisfactory practice is to lay a line of paving stone or brick at right angles to the rail in at least two lengths. The movement of the rail will loosen the joint between the two blocks, but the outside block adjacent to the asphalt will be undisturbed.

Referring to the foot note under the heading "Block Asphalt," on page 35: The reviewer believes that a 4-in. depth of block asphalt is sufficient, and for all practical purposes, as good as a deeper block. He does not agree with the practice of making and laying these blocks flatwise, and 2 or 3 ins. thick, recommended by some of the paving companies.

Granite Block Pavement, paragraph 76, page 39, and foot note: The reviewer's present practice is to use the grout filling, instead of the pitch, in such streets as can be shut up for a sufficient time for the grout to properly harden.

The reviewer questions the advisability of restricting the use of brick (p. 43) to as low a limit as 18%, especially for residence streets of light traffic. He also believes that the provisions requiring bricks adjacent to the curb to be set with their long dimension parallel to the curb is wrong. There should be no breaks in the continuity of a brick pavement, where it is possible to avoid them.

The reviewer also disagrees with paragraph 92, page 47, in which it is specified that the joints between six contiguous courses running across the street from gutter to gutter in each length of 50 ft. be filled with bituminous cement, etc., and also the joints in the longitudinal gutter courses. The reviewer's observation of this method of providing for expansion is that the portion of the street filled with the bituminous cement will wear down very much quicker than the remaining portion of the street, and that unless care is taken to keep the joints open before filling with pitch it does not accomplish the purpose of an expansion joint.

The method described by the author (paragraph 103, page 52) for laying wood block pave-

*City Engineer, Rochester, N. Y.

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ments, wherein he specifies that there should be placed along and against each curb a board having a width 2 ins. greater than the depth of the blocks, ¾-in. thick at its top edge and ½-in. thick at its bottom edge, the paving blocks set against this board and the spaces afterward filled with bituminous paving cement, makes a very much more satisfactory job for brick than that above specified.

The expansion joints, also, across the street, should be about ⅜-in. in thickness, and the brick kept apart by a board not wider than the depth of the blocks, and thoroughly filled with the paving pitch before grouting. This has been the practice of the reviewer for a number of years, and has worked with entire success.

The specifications for wood block pavement, and for laying, appear to be up to date. The reviewer believes the blocks should not be less than 4 ins. in length for streets of heavy traffic. He can see no advantage in anything longer.

Referring to the general specifications relating to all pavements (paragraph 107, page 53): It has been the practice of the reviewer to pay for the entire surface, not making any deductions for any sewer or manhole heads; and also to provide that the contractor shall, in cooperation with the company owning the subways of which these manholes are a part, adjust them properly to grade.

The special guaranty for experimental or untried pavements might be more definite as to the condition of the pavement during and at the expiration of the guaranty.

The pamphlet is a valuable contribution to the literature upon the proper construction of pavements, and will undoubtedly have much influence in standardizing, so far as local conditions will permit, specifications for this kind of work.

Thermodynamics and Chemistry.

Reviewed by J. W. RICHARDS.*

EXPERIMENTAL AND THEORETICAL APPLICATIONS OF THERMODYNAMICS TO CHEMISTRY.—By Dr. Walther Nernst, Professor and Director of the Institute of Physical Chemistry in the University of Berlin. New York: Charles Scribner's Sons. Cloth; 5¼ × 8¼ ins.; pp. 123; eight illustrations in the text and 23 tables. $1.25, net.

This book consists of ten lectures, delivered on the Silliman Foundation at Yale University, Oct. 22 to Nov. 2, 1906, Prof. Nernst being in this instance one of the "exchange" professors coming to us from Germany. No one doubted but that the brilliant pupil of Ostwald, who is esteemed by some as outshining his master, had a message for American scientists, and this book contains it.

Lecture I. is about the general application of thermodynamics to chemistry. It is concerned with the equation $Q = A - T\frac{dA}{dT}$, and gives a very clear, short and definite explanation of its scope and meaning. Lecture II. develops the subject of variation of the heat of chemical reaction with the temperature, as influenced by the heat capacities of the reacting substances and products. From the equation of Lecture I. and these considerations is derived the expression $Q = R\,T^2\frac{d\,ln.\,K}{dT}$, the equation of the reaction isochore. Lectures III. and IV. apply these two fundamental equations to Nernst's experimental researches on the dissociation equilibria of $H^2\,O$, CO^2 and $N\,O$ at high temperatures, showing that the dissociation of these substances can be expressed with great accuracy by the two equations and their mathematical derivations.

Lecture V. discusses the result of integrating the reaction isochore, concluding that A and Q are equal at the absolute zero ($T = 0$), and that at higher temperatures the curves of A and Q diverge by the quantity $T\frac{dA}{dT}$. If we knew the specific heats of all the substances concerned down to $T = 0$, we could calculate Q_0, and so get the fundamental starting point of thermo-chemistry. As T approaches 0, moreover, $\frac{dA}{dT}$ approaches $\frac{dQ}{dT}$. In his illustrations, however, Dr. Nernst drops the chemical equation just as an interesting conclusion seems in sight, and usually ends up with an application of his equation to the process of fusion or evaporation. This emphasizes the application of thermodynamics to physics, and also the inter-relation of physics and chemistry, but is not the application of thermodynamics to chemistry.

Lectures VI. and VII. deal with the evaluation of the constant of integration by means of the curve of vapor pressure. The integration of the reaction isochore having furnished an unknown constant, Nernst makes the assumption that this is a function of the physical properties of the reacting substances, makes use of the doctrine of "corresponding states" as applying to volume relations of gases, and with the "critical point" data as his constants gets coincidences between "calculated" and "observed" heat values which would satisfy no one except a theorist. Either some of the assumptions are unwarranted, or else the data used are unreliable; or else, again, the theory is fundamentally wrong. Which is the case, Nernst does not answer and "deponent sayeth not."

Lectures VIII. and IX. concern the calculation of chemical equilibria in homogeneous gaseous systems, and here again are some coincidences and several discrepancies. The coincidences prove the truth of the theory, and the discrepancies simply need explaining.

The last lecture treats of chemical equilibria in heterogeneous systems, and here considerable light is thrown upon the latent heat of physical changes. It is shown that the "constant" of Trouton's rule increases regularly with the temperature of the boiling point, and so a "Revised Rule of Trouton" is proposed for the heat of *dissociation* of one molecular weight of a substance, which makes it

$$4.57\ (1.75\ log.\ T + 3.0) \times T$$

where the factor of T varies from 30 to 40, between ordinary temperatures and 1,000° C., and at atmospheric pressure.

The last conclusion seems to the reviewer to contain more possibilities of practical value than any other brought forward in the book. Each chemical reaction may be considered as a dissociation, and latent heat simply is heat of opposite sign from heat evolved. The further development of these ideas should furnish us with the key to the critical temperatures of chemical reactions.

Altogether, the chief value of the work is its suggestiveness and stimulus to thought and research. It will be of that value to every one who will "read, mark, learn and inwardly digest" its contents.

*Professor of Metallurgy, Lehigh University, South Bethlehem, Pa.

French Experiments on Sewage Treatment.

Reviewed by EARLE B. PHELPS.*

RECHERCHES SUR L'EPURATION BIOLOGIQUE ET CHEMIQUE DES EAUX D'EGOUT.—(Researches on the Biological and Chemical Purification of Sewage.) Carried out at the Pasteur Institute of Lille and the Experiment Station of Madeleine. By Dr. A. Calmette, assisted by E. Rolants, E. Boullanger, A. Buisine, F. Constant and L. Massol. In two volumes. Paris, France: Masson & Cie. Paper; 6½ × 10 ins. Vol. I.: p. 193; 5 plates and 15 text illustrations. Vol. II.: p. 314; 2 plates, 24 diagrams and 45 text illustrations.

The backwardness of France in matters of sewage disposal and the protection of water supplies gave special significance to the establishment of a sewage experiment station at Madeleine, near Lille; and the names of those in charge of the work and of the Pasteur Institute, which is behind it, gave promise that the opportunity would not be lost.

The results of the first two years study are not disappointing. Aside from the immensely practical value they are bound to have as an appeal for better things in France, they are a decided contribution to the world's literature and knowledge of sewage disposal. [The experimental work reported in these two volumes has been abstracted in another place in this issue.—Ed.]

The first volume or report contains, in addition to the information already mentioned, a full discussion of the methods of analysis employed. The workers are to be particularly commended in that they have undertaken to determine the organic carbon in sewage, a difficult and laborious procedure, but one giving results of great value. There is also a chapter on nitrification studies, a continuation of the most valuable work of Boullanger and Massol on this subject, much of which has already appeared in the "Annales de l'Institut Pasteur," Vols. XVII. and XVIII. A discussion of some work upon chemical precipitation completes the first volume.

The second volume contains, beside the experimental work proper, an illustrated digest of sewage purification in England, Germany, Holland and the United States, a valuable collection of statistics of sewage farms in various countries, and the results of some preliminary investigations of industrial wastes.

*Sanitary Research Laboratory, Massachusetts Institute of Technology, 786 Albany St., Boston, Mass.

HANDBUCH FUR EISENBETONBAU.—Edited by F. von Emperger. Vol. III.: Examples from Practice. Part 2, prepared by R. Wuczkowski, Fr. Lorey, B. Nast, A. Nowak. Berlin, Germany: Wilhelm Ernst & Son. Paper; 7¼ × 10½ ins.; pp. 642; 503 illustrations in the text and one folding plate. 15 marks; American price, $6. Parts 1 and 2, Vol. III., bound together, 34 marks; American price, $13.60.

This second and concluding section of "Examples from Practice" may be described in practically the same words as the first section [reviewed in our issue of May 16, 1907, p. 554], the two together constituting Vol. III of a work on reinforced concrete. The book before us, like its fellow, may be called a descriptive album of reinforced-concrete construction, compiled from quite a variety of sources, and covering work

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The Conquest of the Air.

NAVIGATING THE AIR.—A Scientific Statement of the Progress of Aeronautical Science up to the Present Time. By The Aero Club of America. New York: Doubleday, Page & Co. Cloth; 5 × 8 ins.; pp. xii. + 259; numerous plates and text illustrations. $1.50 net.

THE PROBLEM OF FLIGHT.—A Text-Book of Aerial Engineering. By Herbert Chatley, B. Sc. (Engineering), London. Lecturer in Applied Mechanics, Portsmouth Technical Institute. London, England: Charles Griffin & Co., Ltd. Philadelphia: J. B. Lippincott Co. Cloth; 6 × 9 ins.; pp. 119; 1 plate and 61 text illustrations. $3.50, net.

A collection of papers on subjects connected with ballooning and other phases of aerial navigation has been compiled by a committee of the Aero Club of America, a newly formed sportsmen's organization; supplemented by a profusion of photographs it appears in a volume recently issued. The photographs are excellent, and most of them are interesting. Of the text-matter this cannot be said. It is of most varied character, from various sources; some of the papers are reprints from previous publications in magazines, newspapers, etc., while others, it seems, were "prepared expressly for" the present work. There is a good introductory chapter, by C. Dienstbach, giving a concise review of recent progress in navigating the air, under the curious title "Practical Air Craft." The following chapters, 22 in all, range from brief remarks on the Wright Brothers' Motor Flyer and a discussion by Prof. A. G. Bell of his "tetrahedral" kites, to such varied extremes as suggestions for the complete design of a flying-machine, by Mr. J. P. Holland (containing also a theory that birds fly by virtue of a partial vacuum above their wings, rather than because of plus pressure below the wings), descriptions of balloon trips (including a trip from Cincinnati, O., to South Carolina, in 1861, made by Prof. T. S. C. Lowe), and outlines of experiments on air propellers and kite-sustained aero-planes. There is much in the book to interest the reader, but whether he will glean much knowledge from it is questionable. However, as the purpose of the compilers, apparently, was just that of arousing interest, the book may be considered reasonably successful.

This moderation in seeking to accomplish but little has been very fortunate in this case, if we may judge by another new book on aerial navigation, written by a British mechanics-teacher named Chatley. The book bears the boldly ambitious sub-title: "A Text-Book of Aerial Engineering," but its contents are as far short of what may be expected with reason as the subtitle quoted is beyond the reasonable. A large amount of algebraic work ornaments the pages of the book, but one's a priori faith in the merits of these mathematics is destroyed before many pages are passed. In one example, where the author assumes a flying-machine weighing 2,240 lbs., of which 1,240 lbs. is propelling machinery, driven by a vertical-shaft screw 4 ft. in diameter running at 1,200 r. p. m., he deduces that this machine could lift itself if the engine were capable of producing 66 HP. per lb. of its weight. This would require the 48-in. screw to absorb about 72,000 HP. at 1,200 r. p. m.! But the author says nothing about the impossibility of such a performance. Carrying the example farther, he finds that by using a 10-ft. screw, the engine need produce only 1 HP. per 9.2 lbs. of weight, and the machine would be lifted by the expenditure of 135 HP. The decrease in required power from 72,000 to 135 HP., accomplished merely by increasing the size of the screw without changing its efficiency (for efficiency is not included in the argument) is neither explained nor discussed.

Most of the "engineering" part of the book is no better than the example quoted, in either didactic or practical utility. There are occasional paragraphs that contain raw material from which the reader can extract bits of knowledge. As a whole, however, the chief feature of the book lies in the exhilarating effect of such terms as "heliconef," "airplane," "aeronef" and other novel, important words.

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NATAL GOVERNMENT RAILWAYS.—Report of the General Manager of Railways for the Year 1906. (Edward R. Ross, General Manager.) (Pietermaritzburg, Natal: Pub. Doc.) Paper; 8¼ × 13 ins.; pp. 67; folding and other extra sheets.

This report is in general a compilation of exhaustive tables of statistics, covering the railway development and incidentally reflecting the commercial and industrial development of the colony of Natal. Photographs of railway engineering features supplement the somewhat drier statistical information. The book will be of value to those interested in South African engineering and industrial progress.

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Reinforced-Concrete Buildings.

CONCRETE-STEEL BUILDINGS.—Being a Companion Volume to the Treatise on "Concrete-Steel." By W. Noble Twelvetrees, M. Inst. M. E., Assoc. M. Inst. E. E., Author of "Structural Iron and Steel." London and New York: Whittaker & Co. Cloth; 5 x 7½ ins.; pp. 408; 331 illustrations in the text. $3.25, net.

As stated in the title, the present volume is intended to supplement the author's previous book on "Concrete-Steel,"* which dealt wholly with the materials, concrete and reinforced-concrete. In the later book, detailed accounts are given of various buildings in reinforced concrete which have been built in Europe and America, the original data for which have for the most part appeared in the technical press. The descriptions are very complete, entering into all the details of design and construction, and are very well illustrated with numerous drawings and photographs. No attempt is made to explain the theory of design, all of which is supposed to be covered in the first volume.

It would be, of course, impossible to gather in one book descriptions of all the various reinforced-concrete buildings which have been erected in this country and in Europe; but the author has selected with a good deal of care typical examples of the different uses to which the material has been put. He has described nine terminals and storehouses, nine factory buildings, eight of the office building type, four higher structures, such as churches, theaters, etc., and three coal-bunkers and silos. In addition, six reinforced-concrete failures are noted, together with the lessons to be learned from their poor design or construction. The far greater number of works described have been erected in England or the Continent; many of them are new to American engineers. The few American examples are of buildings well known to engineers, and very fully treated in both periodical and book notes.

The book presents a very satisfactory compilation of work executed in this type of construction, which has developed within the last five years; a construction known as concrete-steel in England, but which is more definitely named reinforced-concrete in this country. It does not claim to be more than a compilation, and very little original matter has been included within its pages. In view of this fact, which is acknowledged by the author, and apparent to the informed reader, there seems to be a lack of knowledge of the ethics and etiquette of authorship on the part of the compiler in not crediting to foreign (i. e., not British) sources such information and drawings as he has obtained from them. Great care has been taken to acknowledge all indebtedness to British publications; to French, German and American authors small consideration is shown.

TABLE OF VOLUMES THROUGH AIR-WAYS.—Cubic Feet per Minute. By C. H. Kuderer. (Allegheny, Pa.: E. E. Meyer). Card; 11¼ x 8 ins. 25 cts.

This table, compiled with the use of Atkinson's formula, will prove handy to hang on the office wall of such as are interested in mine ventilation and kindred subjects. A possible criticism is that the table is printed on a card of a tint suggestive of the glorious Fourth, when white would have made for better clearness and legibility.

THE MINERAL INDUSTRY.—Its Statistics, Technology and Trade during 1906. Founded by Richard P. Rothwell. Edited by Walter Renton Ingalls, M. Am. Inst. M. E., Editor of the "Engineering and Mining Journal." Vol. XV., Supplementing Vols. I. to XIV. New York and London: Hill Publishing Co. Cloth; 6¼ x 9½ ins.; pp. xxiv. + 954; plates and text illustrations. $5.

This continuation of a well-known annual publication carries on the method of presentation of previous issues. The various minerals and metals are accorded individual treatment—the authors of the various divisions being selected for their special fitness for the subjects treated.

The book is over 200 pages larger than any previous edition. About four-fifths of the space is devoted to individual treatment of minerals and metals, and the remainder to literature review, technical progress, and statistics of production of various countries.

Among the more prominent contributors are Prof. Bradley Stoughton, of the Columbia University School of Mines; W. R. Ingalls, Editor of the "Engineering and Mining Journal;" Prof. R. H. Richards, of the Chair of Mining, Massachusetts Institute of Technology; and Thos. W. Gibson, Deputy Minister of Mines of Ontario, who has treated the Cobalt mining district.

*Reviewed in Engineering News, Sept. 14, 1905, p. 201.

Publications Received.

ALABAMA COAL MINES.—Report of Inspector, Showing the Location of Mines, Character, Production, Employees, etc., for the Year 1906. J. M. Gray, Chief Mine Inspector. Birmingham, Ala.: Charles E. Bowron. Paper; 6 x 9¼ ins.; pp. 36. 10 cts.

AMERICAN PUBLIC WORKS ASSOCIATION.—Second Convention, Atlanta, Ga., Sept. 14 and 15, 1906. (William H. Flint, Secy., Chattanooga, Tenn.) Cloth; 6 x 9 ins.; pp. 183; illustrated.

AMERICAN RAILWAYS AS INVESTMENTS.—A Detailed and Comparative Analysis of All the Leading Railways, from the Investor's Point of View: With an Introductory Chapter on The Methods of Estimating Railway Values. By Carl Snyder. New York: The Moody Corporation. London, England: Frederic C. Mathieson & Sons. Cloth; 6¼ x 9½ ins.; pp. 762; one folding map. $3.20, net; by mail, $3.40.

BULLETINS, BUREAU OF THE CENSUS.—S. N. D. North, Director. Washington, D. C.: Pub. Doc. Paper; 9¼ x 11½ ins.

No. 78: Census of Manufactures: 1905. Iron and Steel and Tin and Terne Plate. Pp. 105.

BULLETINS, OFFICE OF PUBLIC ROADS.—Logan Waller Page, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ x 9 ins.

No. 29: The Construction of Macadam Roads. By Austin B. Fletcher, Special Agent, Office of Public Roads. Pp. 56: 6 plates and 10 text figures.

No. 30: The Corrosion of Iron. By Allerton S. Cushman, Assistant Director, Office of Public Roads. Pp. 35; 7 plates and 3 text figures.

BULLETINS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ x 9 ins.

No. 317: Preliminary Report on the Santa Maria Oil District, Santa Barbara County, California. By Ralph Arnold and Robert Anderson. Pp. 69; two plates (one in pocket) and one text figure.

COMMISSIONER OF EDUCATION.—Report for the Year Ending June 30, 1905. Vol. 2. Washington, D. C.: Pub. Doc. Cloth; 5¾ x 9¼ ins.; pp. 657 to 1400.

A COURSE IN STRUCTURAL DRAFTING.—A Description of Material Used in Structural Design and Drafting Room Practice Relating to Same, with a Few Plates for the Student. Compiled and Arranged by W. D. Browning, Author of "Dimensions of Pipe, Fittings and Valves," etc. Collinwood, O.: The Industrial Magazine. Flexible cloth; 6 x 9 ins.; pp. 64; folding plates and text illustrations. $1.

IMPERIAL RAILWAY BUREAU.—Annual Report for the Year 1905-1906. Ministry of Communications. (Ichiji Yamanouchi, Director of Bureau.) Tokyo, Japan: Pub. Doc. Paper; 8¾ x 12 ins.

INDIANA ENGINEERING SOCIETY.—Proceedings of the 27th Annual Meeting, Held at Indianapolis, Jan. 17-19, 1907. Indianapolis, Ind.: The Society (Charles C. Brown, Secy., 408 Commercial Club Building). Paper; 6 x 9 ins.; pp. 212; illustrated.

KURZES LEHRBUCH DER ELEKTROTECHNIK.—By Dr. Adolf Thomälen. Third edition. Berlin, Germany: Julius Springer. Cloth; 6¼ x 9¼ ins.; pp. 525; 338 illustrations in the text. 12 marks; American price, $4.80.

LUBRICATION AND LUBRICANTS.—A Treatise on the Theory and Practice of Lubrication, and on the Nature, Properties and Testing of Lubricants. By Leonard Archbutt, F. I. C., F. C. S., Chemist to the Midland Railway Co., and R. Mountford Deeley, M. Inst. M. E., F. G. S., Locomotive Superintendent, Midland Railway. Second Edition, Thoroughly Revised and Enlarged. London, England: Charles Griffin & Co. Cloth; 5¼ x 8¾ ins.; pp. xxx. + 528; 157 illustrations in the text. $6, net.

MANUFACTURES, 1905. Bureau of the Census (Special Reports); S. N. D. North, Director. Part 1. United States by Industries. Washington, D. C.: Pub. Doc. Cloth; 9 x 12 ins.; pp. ccclxix. + 680; 16 maps and 26 diagrams.

THE MINING AND QUARRY INDUSTRY OF NEW YORK STATE.—Report of Operations and Productions during 1906. By D. H. Newland. Bulletin 112, Economic Geology 16, New York State Museum; John M. Clarke, Director. Albany, N. Y.: Pub. Doc. Paper; 6 x 9 ins.; pp. 80.

NATIONAL FIRE PROTECTION ASSOCIATION.—Proceedings of the 11th Annual Meeting, Held in New York May 22-24, 1907. Chicago, Ill.: The Association (W. H. Merrill, Jr., Secy., 382 Ohio St.). Stiff paper; 5¾ x 9 ins.; pp. 415; plates and text illustrations.

THE NEW HAMPSHIRE REGISTER, YEAR BOOK AND BUSINESS DIRECTORY FOR 1907.—Revised to April 15, 1907. Concord, N. H.: New Hampshire Register Co. Paper: 4 x 6 ins.; pp. 299. 25 cts.

PORT OF PARA, BRAZIL.—By Elmer L. Corthell. Brussels, Belgium: Permanent International Association of Navigation Congresses (Alexis Dufourny, Secy., 38 Rue de Louvain). Paper; 6 x 9¼ ins.; pp. 13; five folding plates.

SANITARY CHEMICAL EXAMINATION OF WATER BACTERIA.—Andrew Watson Sellards. (Reprinted from "The Journal of Infectious Diseases," 1907, Supplement No. 3.) Paper; 6½ x 9½ ins.; pp. 41 to 49.

STEREOTOMY.—By Arthur Willard French, M. Am. Soc. C. E., Professor of Civil Engineering, Worcester Polytechnic Institute, and Howard Chapin Ives, Assistant Professor of Civil Engineering, University of Pennsylvania. Second Edition. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5¾ x 9¼ ins.; pp. 119; 47 illustrations, mostly in the text, and 22 folding plates. $2.50.

SURVEY OF OYSTER BARS.—Anne Arundel County, Maryland. Description of Boundaries and Landmarks and Report of Work of United States Coast and Geodetic Survey in Cooperation with Maryland Shell Fish Commission. By C. C. Yates, Assistant and Chief of Party, Coast and Geodetic Survey. Washington, D. C.: Pub. Doc. Paper; 7½ x 11½ ins.; pp. 106; one folding plate.

TRADE, SHIPPING, OVERSEA MIGRATION, AND FINANCE, OF THE COMMONWEALTH OF AUSTRALIA.—For the Month of April, 1907. By G. H. Knibbs, F. R. S. S., Commonwealth Statistician. Bulletin No. 4, Commonwealth Bureau of Census and Statistics, Melbourne. Melbourne, Australia: Pub. Doc. Paper; 8¼ x 13 ins.; pp. 26.

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